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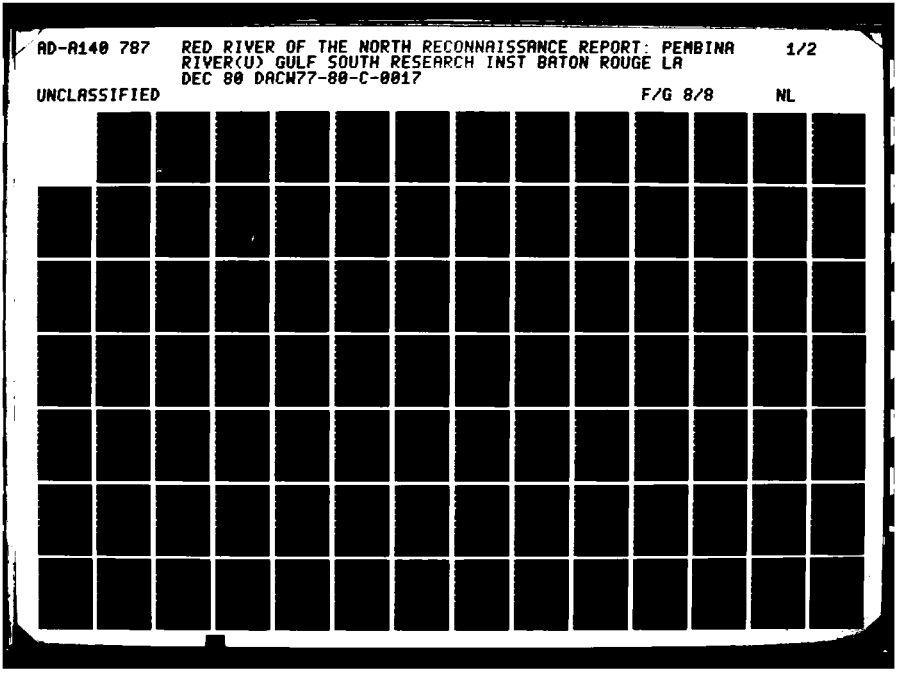

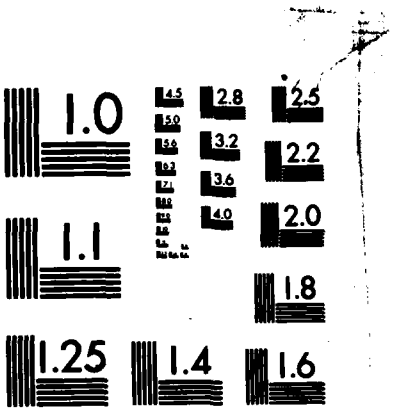

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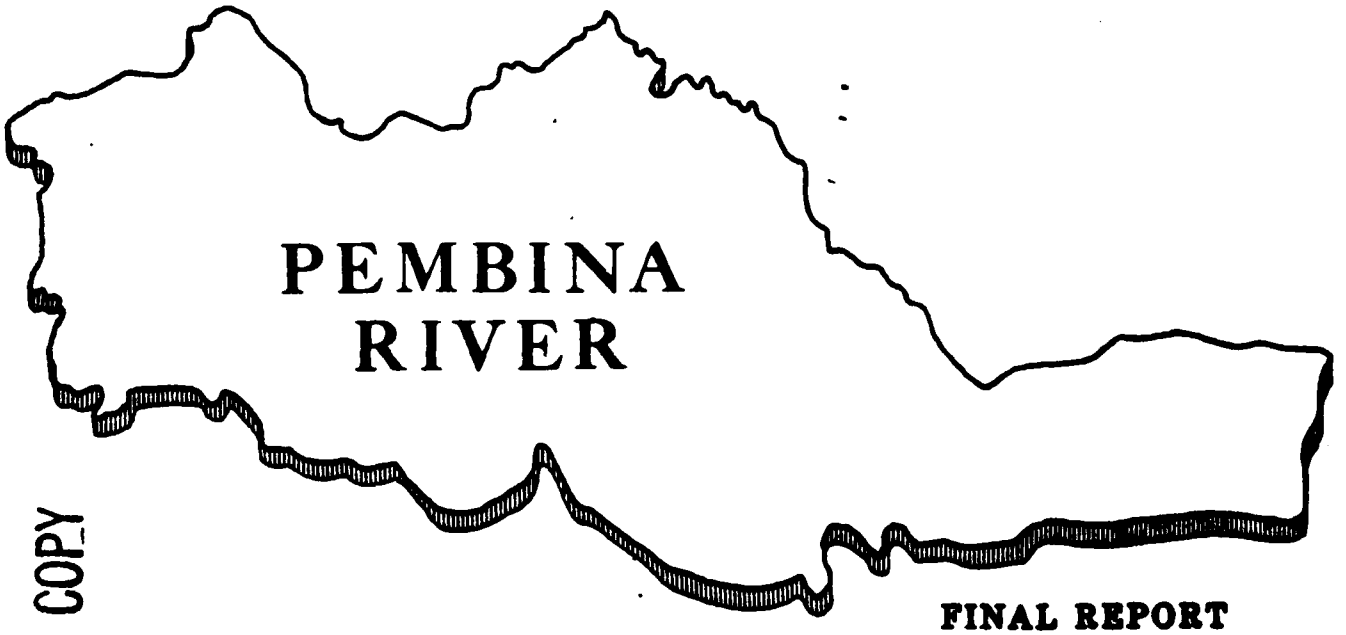

FINAL REPORT
December 1980

ST. PAUL DISTRICT: U.S. ARMY CORPS OF ENGINEERS

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report is one of 23 subbasin reports produced by the St. Paul District Corps of Engineers in connection with a reconnaissance report for the whole of the Red River Basin. The reconnaissance report is itself part of the overall Red River of the North study, which was initiated by Congress in 1957 in order to develop solutions for flooding problems within the basin.

The purpose of a reconnaissance study is to provide an overview of the water and related land resource problems and needs within a particular geographic area, to identify planning objectives, to assess potential solutions and

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problems, to determine priorities for immediate and longrange action, and to identify the capabilities of various governmental units for implementing the actions.

The information developed in this report has been combined with information developed in the other subbasin reports to produce a main report covering the basin as a whole. The various flood control measures discussed in this and in other subbasin reports are combined in the main report to develop the outline of an integrated flood control plan for the basin within the context of a comprehensive plan.

The Pembina River Subbasin lies in the south-central portion of Manitoba Province in Canada and in the northeastern part of North Dakota in the United States. The subbasin length (east to west) is about 130 miles, and its width (north to south) varies from a maximum of about 35 miles in the western portion to about 18 miles in the eastern portion. The total area is approximately 3,950 square miles, of which about 50.3 percent is in Canada and 49.7 percent is in the United States. The United States portion includes parts of Rolette, Towner, Cavalier, and Pembina counties. It is bordered on the south by the Devils Lake and Park subbasins and on the east by the Main Stem Subbasin.

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RECONNAISSANCE REPORT: RED RIVER OF THE NORTH BASIN PEMBINA RIVER SUBBASIN

Prepared for:

U.S. Army Corps of Engineers
St. Paul District
St. Paul, Minnesota

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The purpose of a reconnaissance study is to provide an overview of the water and related land resources problems and needs within a particular geographic area, to identify planning objectives, to assess potential problems and solutions, to determine priorities for immediate and long-range action, and to identify the capabilities of various governmental units for implementing the actions.

The Pembina River Subbasin is a water resource planning unit located in the northern North Dakota portion of the Red River Basin. This report describes the social, economic, and environmental resources of the subbasin, identifies the water-related problems, needs, and desires, and suggests measures for meeting the needs, particularly in the area of flood control.

The report was prepared almost entirely on the basis of secondary information. However, some telephone contacts were made to verify information and to acquire a more complete picture of local conditions. The comprehensive reports available on the subbasin include the following: (1) Joint Investigation For Development of the Water Resources of the Pembina River Basin, Manitoba and North Dakota, Volumes I, II and III, Main Report and Appendices, which was published by the International Pembina River Engineering Board in 1964; (2) Plan of Survey For an Interim Survey for Flood Control and Related Purposes on Pembina River, North Dakota, which was published by the St. Paul District Corps of Engineers in 1970; (3) Emergency Snagging and Clearing for Flood Control Reconnaissance Report, Pembina River, North Dakota, which was published by the St. Paul District Corps of Engineers in 1975; and (4) Pembina River North Dakota, Feasibility Report For Flood Control and Related Purposes, Summary and Appendices, which was published by the St. Paul District Corps of Engineers in 1976. Other published sources on the subbasin include:

1. The Vascular Flora of Pembina County, North Dakota, Reprinted from The Prairie Naturalist, Vol. 3, Nos. 3 and 4, pp. 80-104, which includes a brief description of Pembina County and a list of all native or naturalized plants in the county.

2. Work Plan, Tongue River Watershed of the Red River of the North Watershed, Cavalier and Pembina Counties, North Dakota, which was published in 1955 by the U.S. Department of Agriculture, Soil Conservation Service, and is a study to determine the feasibility of proposed erosion and flood control measures.

3. Water Resources Planning and Development in North Dakota, A Status of Corps of Engineers Studies, which was published in 1979 by the St. Paul District Corps of Engineers and describes a proposed earthen dam for flood control, water supply, and recreation on the Pembina River near Walhalla.

4. Section 205-Detailed Project Report For Flood Control, Red River of the North at Pembina, North Dakota, which was published in 1971 by the St. Paul District Corps of Engineers and describes a flood protection project on the Red River of the North at Pembina, North Dakota.

5. Proposal For Snagging and Clearing the Pembina River In North Dakota From Its Mouth, Upstream to Walhalla, North Dakota, which was published by the St. Paul District Corps of Engineers in 1974 and is a description of the area of the proposed project and the work to be undertaken.

6. Final Environmental Impact Statement, Pembina River, N.D., Clearing and Snagging, which was published in 1977 by the St. Paul District Corps of Engineers and describes a proposed project involving snagging and clearing along 33 miles of the Pembina River between Pembina and Neche, North Dakota.

7. Statement of Findings, Snagging and Clearing For Flood Control, Pembina River, North Dakota, which was published in 1977 by the St. Paul District Corps of Engineers and describes alternatives and a selected plan for reducing flood damages along the river.

8. Archaeological Site Survey of the Pembilier Project Area, which was published by the St. Paul District Corps of Engineers in 1975 and contains survey findings of the Pembina River Coulee in the Pembilier project area east of the Pembina's confluence with its North Fork and along the Little Pembina River.

9. Draft Environmental Impact Statement, Pembilier Lake and Dam, Pembina River Basin, North Dakota, which was published by the St. Paul District Corps of Engineers in 1976 and describes the project and its environmental consequences.

In addition, the subbasin received partial coverage in the Souris-Red-Rainy River Basins Comprehensive Study, which was published by the Souris-Red-Rainy River Basins Commission in 1972, and in the Red River of the North Basin Plan of Study, which was published by the St. Paul District Corps of Engineers in 1977.

The information developed in this report has been combined with information developed in the other subbasin reports to produce a main report covering the basin as a whole. The various flood control measures discussed in this and in other subbasin reports are combined in the main report to develop the outline of an integrated flood control plan for the basin within the context of a comprehensive plan.

II. DESCRIPTION OF STUDY AREA

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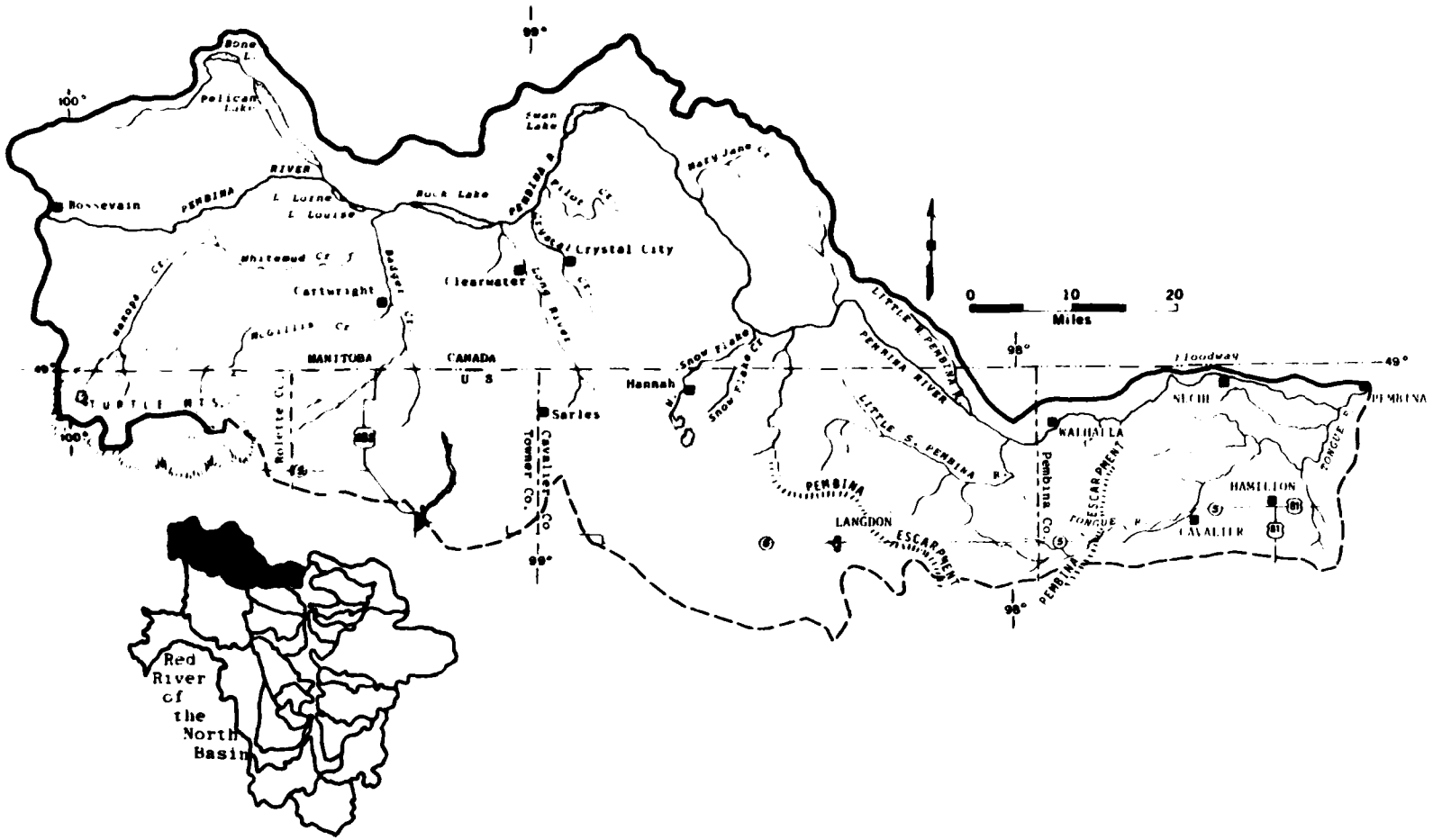
The Pembina River Subbasin lies in the south-central portion of Manitoba Province in Canada and in the northeastern part of North Dakota in the United States (Figure I). The subbasin length (east to west) is about 130 miles, and its width (north to south) varies from a maximum of about 35 miles in the western portion to about 18 miles in the eastern portion. The total area is approximately 3,950 square miles, of which about 50.3 percent is in Canada and 49.7 percent is in the United States. The United States portion includes parts of Rolette, Towner, Cavalier, and Pembina counties. It is bordered on the south by the Devils Lake and Park subbasins and on the east by the Main Stem Subbasin.

The subbasin includes parts of two well-defined topographic subdivisions of the Interior Plains region of North America: the Drift Prairie Plateau in the west and the Red River Valley in the east. A rugged strip of terrain, the Pembina Escarpment, separates the two plains regions.

The eastern 32-38 miles of the subbasin lie in the Red River Valley. This is the lowest section of the subbasin and was formed by the recession of glacial Lake Agassiz. The area is a featureless plain that rises gently from an elevation of 790 feet at the city of Pembina, North Dakota, to 1,000 feet at the foot of the Pembina Escarpment. The flat surface of the plain is broken only by drainages and several low, sandy ridges that have a general northwest-southeast trend. These ridges mark the shoreline of Lake Agassiz as it receded.

The portion of the subbasin in Canada and west of the escarpment in the United States lies entirely within the Drift Prairie. With the exception of the Turtle Mountains, an elevated tableland located in the extreme western portion of the subbasin, the drift prairie is an undulating, poorly drained surface that slopes from an elevation of 1,800-feet at the base of the Turtle Mountains to 1,500 feet at the crest of the Pembina Escarpment 80 miles to the east. The surface is dotted with morainic hills, ridges, and undrained depressions occupied by lakes, sloughs, and alkali swamps.



Source: Gulf South Research Institute.

Figure I. PEMBINA RIVER SUBBASIN

The Pembina River is the northernmost tributary of the Red River of the North. The river has its source about 10 miles south of Boissevain, Manitoba in the area of the Turtle Mountains. The main stem flows east across southern Manitoba, then southeast across the international boundary into North Dakota, after which it turns eastward in a winding course across northern North Dakota. About two miles south of the international boundary near the community of Pembina, North Dakota, the stream empties into the Red River of the North. The total length of the Pembina River is about 310 miles.

Over the upper reach of its course in Canada, the river flows in a progressively deepening channel until it reaches the Pembina Valley lake area near the east end of Pelican Lake. From the vicinity of Pelican Lake downstream through Swan Lake, the river is carried in a wide, flat valley. Deep coulees entering the valley in this area have deposited alluvium and sediments over the valley floor forming natural dams which have created valley lakes, including Bone, Pelican, Lorne, Louise, Rock, and Swam lakes. Downstream from Swan Lake, the Pembina River flows in a progressively deeper and wider valley. Near Walhalla, North Dakota, the valley rapidly decreases in size and soon disappears completely in a broad, flat plain that is at the same elevation as, or lower than, the riverbanks.

The principal tributaries of the Pembina River are Badger Creek, Long River, Little South Pembina River, and Tongue River, which have drainage areas of 832, 293, 182, and 4/9 square miles, respectively. Relatively minor tributaries include Crystal, Pilot, Mary Jane, Snowflake, and Mobray creeks and Little North Pembina River.

III. PROBLEMS, NEEDS, AND DESIRES

III. PROBLEMS, NEEDS, AND DESIRES

The primary water-related problems, needs, and desires in the Red River Basin are flood control, fish and wildlife conservation and enhancement, recreation, water supply, water quality, erosion control, irrigation, wastewater management, and hydropower. Various water-related problems, needs, and desires have been identified for the Pembina River Subbasin in previous planning reports on the basis of analysis of conditions and public and agency comments. The list of problems, needs, and desires for the subbasin is the same as the list for the Red River Basin as a whole, with the exception of hydropower. Each problem is discussed separately below, with an emphasis on flooding problems.

Flooding Problems

Nature of the Problems

An important aspect of the flooding problem is that the topography of the subbasin does not generally produce high flows. The large percentage of the area that is poorly drained, together with areas that are non-contributing drainage, reduces the magnitude of the flood flows below that which might normally be expected from such a large drainage area. In some parts of the subbasin, however, steep valley slopes do produce rapid runoff.

Flooding along the Pembina and its tributaries nearly always occurs during the spring as a result of rapid snowmelt, sometimes accompanied by rainfall, or from heavy spring rains following snowmelt when conditions are especially favorable for high runoff. Factors affecting the size of spring floods include: the moisture contained in the snow cover (one to 2½ feet are common), the depth of frost penetration, temperature variations during breakup, and the occurrence of spring rains. The latter have been known to prolong some of the snowmelt floods or cause subsequent floods after snowmelt runoff. Such floods usually lead to delays in planting operations and result in reduced crop yields.

Unlike other Red River subbasins, general summer storms typically do not occur over large areas of the subbasin. Consequently, floods are rare in the summer months, although some increased streamflow does occur.

No floods are known to have occurred in the fall or winter months. In addition, lakes in the upper valley, in effect, absorb runoff from the area above their outlets so that flood peaks downstream are reduced.

Two separate types of flooding occur: the most damaging type associated with river bank overflow (overbank flooding) and another type caused by runoff from snowmelt or heavy rainfall impounded by plugged culverts and ditches within sections of land bounded by roadways on earthen fill (overland flooding). In overland flooding, the trapped water slowly accumulates until it overflows the roadways and inundates section after section of land as it moves overland in the direction of the regional slope until reaching river or stream channels.

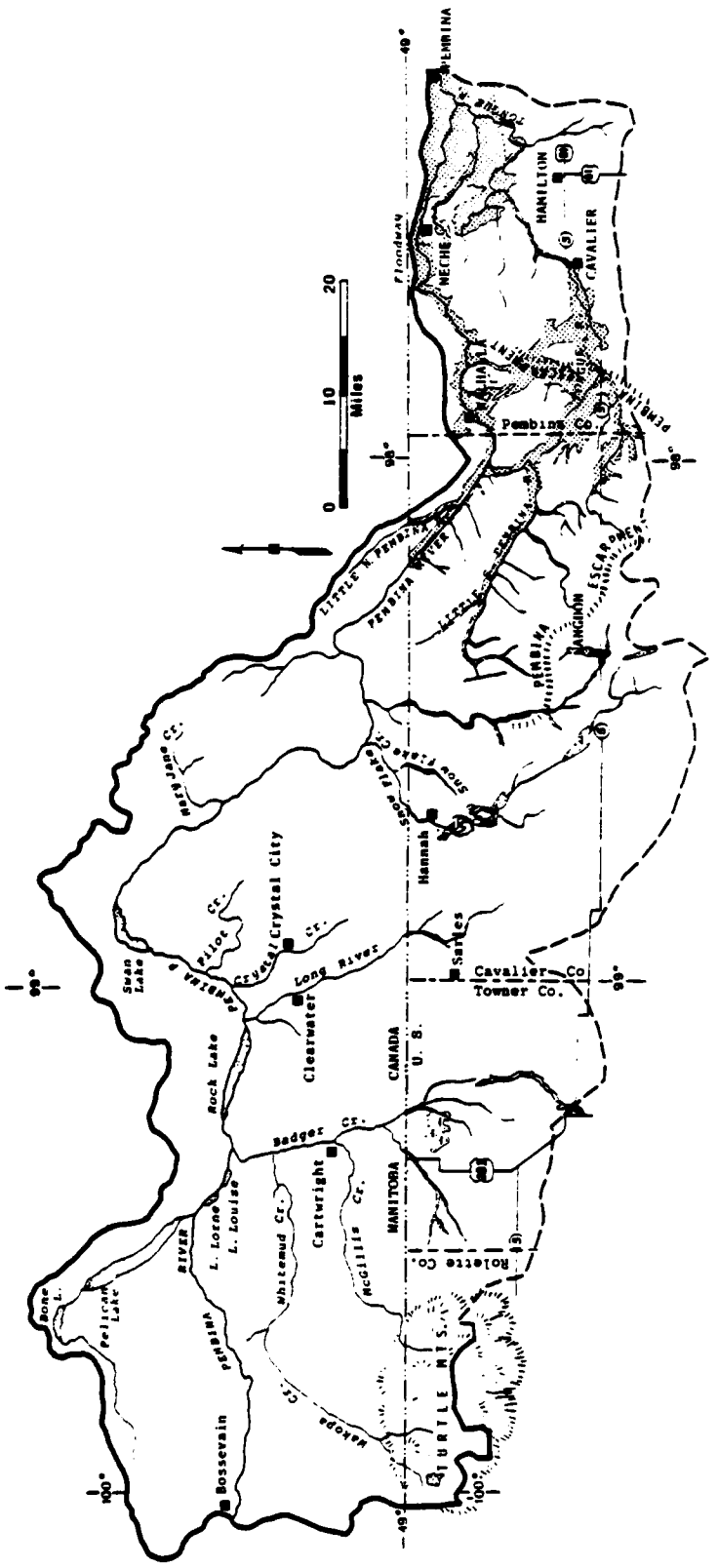
As discussed in the following section, damaging floods generally occur primarily east of the Pembina Escarpment. In this area the land is very flat and banks are low, enabling flows to inundate considerable areas. Prior to the construction of border dikes in U.S. and Canada, a reduction in peak flows between Walhalla and Neche always occurred because of the overland escape of waters into other watersheds.

Flows are also restricted by snags, fallen trees, debris, and slides caused by undermined trees. In addition to such localized flooding, flood flows contribute to the overall magnitude and duration of flooding on the main stem Red River. The Pembina drainage in the U.S. area accounts for 5.0 percent of the total Red River basin and just over 10 percent of the total Red River flow at the international boundary.

Location and Extent

Figure II depicts the 100-year floodplain for the subbasin. A number of sources were investigated in order to produce the present delineation. Among these were: (1) U.S. Geological Survey (USGS) Flood Prone Area Maps at 1:24,000 scale; (2) Corps of Engineers photomosaics of the 1979 flood; (3) published secondary sources describing flooded areas; and (4) USGS 7½ minute topographic maps.

The map is thus a composite of available sources supplemented by inferences where necessary. Because the sources were incomplete and



Source: Gulf South Research Institute.

Figure II. 100-YEAR FLOODPLAIN

based on surveys differing in purpose and accuracy, it should be understood that Figure II constitutes a general delineation intended only for general planning purposes. A more complete description of sources and limitations is given in Appendix A.

According to this initial delineation, the U.S. portion of the Pembina River floodplain comprises approximately 142,000 acres. Major components include the Pembina proper, 52,000 acres; the Tongue, 68,000 acres; Little South Pembina, 6,000 acres; another 6,000 acres west of the Little South Pembina; and 10,000 acres of associated wetland in the central and western parts of the subbasin.

Of the total floodplain acreage of the Pembina proper, some 6,000 acres are normally associated with main stem Red River flooding. Another 6,000 acres occur west of the escarpment. This is much like the floodplain of the Tongue; i.e., 6,000 acres are part of the main stem Red River area, and 10,000 acres occur west of the escarpment. Figure II indicates widths of both the Pembina and Tongue River floodplain as varying from a quarter mile in the area west of the escarpment and in the corridor north of the city of Cavalier to several miles in the areas adjacent to the Red River and Pembina Escarpment.

Other floodplain areas west of the escarpment include the Little South Pembina (6,000 acres), miscellaneous smaller creeks farther west (6,000 acres), and associated marsh areas in the same vicinity (10,000 acres). With the exception of the latter, widths are generally less than one quarter mile.

Overall, the delineation in Figure II correlates well with various acreage estimates in published sources, but there are discrepancies even there. For example, the USGS Flood Prone Area maps indicate a somewhat larger area of inundation in the main stem Red River area than is shown in the Souris-Red-Rainy Type II report. The 1979 photomosaics, in turn, indicate a greater extent of flooding in the area northwest of Walhalla than is shown on the individual Flood Prone Area map. In cases such as these, the more extensive area was utilized. In the acreage estimates, the dividing line between the Pembina and Tongue River floodplains was necessarily arbitrary.

Flood Damages

The primary areas affected by flooding throughout the subbasin's floodplain are urban, agricultural and environmental in nature. The towns of Pembina, Neche, and Walhalla are the urban areas in the floodplain of this subbasin. The only damage categories taken into account in the computation of average annual damages are urban and rural.

Present average annual damages in the subbasin are estimated at $2.8 million. This is one of the largest average annual damage figures in the entire basin, accounting for eight percent of the Red River of the North basin-wide total. Average annual damages are separated into two basic classifications: urban and rural. Damages to residences, businesses (commercial and industrial) and public facilities (streets, utilities, sewers, etc.) are reported as urban damages. Damages to crops, other agricultural assets (fences, machinery, farm buildings, etc.) and transportation facilities are reported as rural damages. Rural damages account for 94 percent of the total average annual damage figure for the subbasin, and urban damages account for the remaining six percent.

Urban flood damages sustained during the 1979 flood event amounted to $205,000. No urban flood damages were reported to have resulted from the 1975 flood event. Average annual urban flood damages in the subbasin are estimated at $162,800. A more detailed breakdown of these urban flood damage figures is presented in Table 1. Urban damages resulting from the 1979 flood event included $102,500 in residential damages, $82,000 in damages to businesses, and $20,500 in public damages. Average annual urban flood damages are estimated at $81,400 in residential damages, $65,100 in business related damages and $16,300 in public types of damages.

Average annual rural flood damages and the rural flood damages incurred in the 1979 flood event are shown in Table 2. Rural flood damages sustained in the 1979 flood event included $4.6 million in crop damages, $660,000 in other agricultural damages and $340,000 in transportation damages. In comparison, average annual rural flood damages are estimated at $1.8 million in crop damages, $600,500 in other agricultural damages and $227,800 in transportation damages. Total rural flood damages were $5.6 million in the 1979 flood event and $2.6 million on an average annual basis.

Table 1

PEMBINA RIVER SUBBASIN, ESTIMATED 1979 AND AVERAGE ANNUAL URBAN FLOOD DAMAGES (Thousands of 1979 Dollars)

	Urban Flood Damage	
Category	1979	Average Annual
Residential	$102.5	$ 81.4
Business	82.0	65.1
Public	20.5	16.3
TOTAL	$205.0	$162.8

Sources: Red River of the North Basin Plan of Study, April, 1977; Post Flood Report, 1979; and Gulf South Research Institute.

Table 2

PEMBINA RIVER SUBBASIN, ESTIMATED 1979 AND AVERAGE ANNUAL RURAL FLOOD DAMAGES (Thousands of 1979 Dollars)

	Rural Flood Damage	
Category	1979	Average Annual
Crop	$4,564.0	$1,801.4
Other Agricultural	660.0	600.5
Transportation	340.0	227.8
TOTAL	$5,564.0	$2,629.7

Sources: Red River of the North Basin Plan of Study, April, 1977; Post Flood Report, 1979; and Gulf South Research Institute.

Environmental Concerns

The Souris-Red-Rainy River Basins Commission (1972) reported that the state of North Dakota has a smaller percentage of woodlands than any of the 50 states, with a total of about 400,000 acres of natural timber. The Commission indicated that the Turtle Mountains in the Souris River Basin and the Pembina Hills and Devils Lake area in the Red River Basin constitute the most important remaining areas of natural woodlands. Approximately 252,000 acres of forest remain in these three areas. These areas are considered even more significant now because the construction and filling of Garrison and Oahe Reservoirs and extensive clearing between these two lakes has reduced major bottomland hardwood formations along the Missouri River. The forests in the three areas provide high-value habitats for wildlife and for outdoor recreation associated with wildlife and are excellent aesthetic attractions.

The Commission indicated further that about 35 percent of the forests in the three abovementioned areas had been cleared in the past 20 years. Although the State provides tax abatements for woodland maintenance, the clearing has not been reduced. Further, the native timber in these areas has little market value, and landowners are apparently not provided with an adequate incentive to save them. The U.S. Army Corps of Engineers (1977a) stated that annual rates of clearing for Pembina, Cavalier, Towner, and Rolette counties during 1958-1967 were 1.0, 3.6, 3.4, and 0.1 percent, respectively.

Table 3 provides data on the woodland acreages remaining in the Turtle Mountains, Upper Pembina Valley, and Devils Lake areas. The table shows that 28,200 acres of woodlands are in public ownership; the remaining 223,800 acres are privately owned and subject to clearing. The Souris-Red-Rainy River Basins Commission (1972) reported that a ten-year program, involving the State Forest Service, State Parks and Recreation Agency, and State Game and Fish Department, could be developed to acquire the remaining woodlands. The State Outdoor Recreation Agency, State Highway Department, and State Water Commission would provide important technical, engineering, and legal assistance.

Table 3

WOODLAND PRESERVATION AREAS IN NORTH DAKOTA

Area	Existing Woodland (Acres)	Publicly Owned Woodlands (Acres)	Woodlands Remaining to Be Acquired to Assure Preservation of the Area (Acres)
Souris River Basin			
Turtle Mountain*	125,000	20,700	104,300
Red River of the North Basin			
Upper Pembina Valley	84,000	5,770	78,230
Devils Lake Area	43,000	1,730	41,270
TOTAL	252,000	28,200	223,800

*An undetermined amount of acreage in this area falls within the Pembina River Subbasin.

Source: Souris-Red-Rainy River Basins Comprehensive Study, Appendix J, Fish and Wildlife.

The U.S. Army Corps of Engineers (1977) indicated that the Deputy State Forester emphasized the need for the State to concentrate its forestry efforts in Pembina and Cavalier counties, where the largest contiguous blocks of native forest remained and where maximum results could be expected. These two counties, along with Walsh and Grand Forks, were considered to have the greatest rate of clearing in the state and had lost 27,897 acres, or 27 percent of their 1956 forest land base acreage, to agriculture. Woodland losses have proceeded at the rate of about three percent each year and have involved approximately 76,000 acres, 90 percent of which was in the Pembina Subbasin.

The information presented above indicates the pressing need to protect the remaining woodlands of the subbasin, since they are extremely significant habitats for wildlife, are important for wildlife-oriented recreation, and are of exceptional aesthetic value.

Needs have been expressed for state wildlife management lands within Cavalier, Pembina, Rolette, and Towner counties. These needs, expressed in acreage values, are shown in Table 4. The goal acreages are cumulative in that they should be added to the 1967 acreage value to give the actual total desired under state ownership.

Table 4

STATE WILDLIFE MANAGEMENT AREA NEEDS FOR THE FOUR COUNTIES INCLUDED BY THE PEMBINA RIVER SUBBASIN

County	1967 Acreage	Goal Acreages* 1980	2000	2020
Cavalier	748	6,400	16,400	16,400
Pembina	2,240	6,400	16,400	16,400
Rolette	5,178	3,200	9,600	9,600
Towner	23	4,800	7,700	7,700

*Goal acreages are cumulative in that they should be added to the 1967 acreage value to yield the actual total needed under state ownership.

Source: North Dakota Game and Fish Department in Souris-Red-Rainy River Basins Comprehensive Study, Appendix J, Fish and Wildlife.

Numerous wetlands and most of the native prairie in the subbasin have been eliminated in favor of agricultural land uses, especially in the eastern portion. These areas are very productive wildlife habitats and, in the case of wetlands, serve a variety of other beneficial functions. There is a need to protect, conserve, and enhance where possible these sensitive ecosystems in the subbasin (U.S. Fish and Wildlife Service, 1979).

Low flows during certain periods of the year and poor water quality, especially high sediments, are factors which are degrading habitats for aquatic biota in the streams of the subbasin. The problem is aggravated by silt-laden flood flows during the spring. Winter and summer fish kills are known to occur in Rock and Pelican Lakes, Canada, as a result

of shallow water and high BOD. Most other lakes in the subbasin do not support year-round fish populations because of shallow water conditions. Rainbow and brown trout have been stocked in Renwick Reservoir and below the dam, but recurring winter kill conditions presently prevent success of this program. Upstream fish movements are prevented between Walhalla and the confluence of the Tongue River and the Pembina River during normal flow by the presence of two low-head dams. However, the fish are able to move past these obstructions during the high water period (spring runoff), when the dams become submerged (U.S. Army Corps of Engineers, 1977a).

Aquatic vegetation is lacking in most areas, probably because of high flows, silt deposition, scouring during spring runoff, and low flows at other times of the year. Periphyton is nearly absent on suitable substrates such as rocks because of a silt coating (U.S. Army Corps of Engineers, 1977a).

Recreation Problems

Recreation problems in the subbasin stem from the scarcity of natural lakes. Recreation opportunities are particularly limited in the western portion of the subbasin and in the level area east of the escarpment.

The fishing potential of the lower reaches of the Pembina, Tongue, and Little Pembina rivers has been limited by intermittent flows and water quality problems as a result of municipal effluents and agricultural runoff discharged into the streams. Most of the natural lakes and several artificial impoundments in the subbasin are subject to severe winter and summer kill conditions.

The 1975 North Dakota State Comprehensive Outdoor Recreation Plan identified primary needs in the area as swimming, boating, hiking, fishing, and camping. Snow-skiing and snowmobiling are the primary winter activity needs.

Water Quality Problems

The water quality in the Pembina River is considered good. Problem parameters include low dissolved oxygen, high nitrates, and high phosphates. Intermittent flows also create water quality problems such as decreased

oxygen levels. The excessive levels of nitrates and phosphates are a result of non-point sources such as agricultural runoff. The municipal effluents, at this time, appear to be of an adequate quality. Wastewater management will be discussed in a later section (North Dakota Statewide 208 Water Quality Management Plan, 1978; Shewman and North Dakota State Department of Health, no date). The U.S. Army Corps of Engineers (1977) reported TDS violations on the Pembina River 65 percent of the time.

The Upper Mississippi River Basin Commission (1977) states there was an insufficient supply of developed groundwater sources to meet the projected population and industrial expansion. Groundwater supplies are presently limited and contain excessive concentrations of iron, sulphates, and dissolved solids.

Water Supply Problems

A lack of adequate water supply has been one of the principal obstacles to industrial development in the area east of the escarpment. Industries dependent on agricultural projects for raw materials have been reluctant to locate in the Pembina Subbasin because of the poor water supply conditions. Groundwater supplies of good quality are very limited in distribution and quantity and are usually found in the beach or shore deposits of Glacial Lake Agassiz. An excess of iron, sulfates, and dissolved solids is usually found in groundwater sources. The majority of the aquifers in the area are shallow and recharged by direct infiltration of local precipitation. In some areas, farmers must rely on hauled water since it has been impossible to develop any large wells. Due to a low population and industrial density, groundwater pollution has generally not been a problem.

The chemical quality of surface water is usually better than that of groundwater. However, the quality of the Pembina River water varies seasonally and throughout the length of the stream.

Increase in population and water use by the area served by Neche would result in water supply needs which could only be partially met by existing sources.

Erosion Problems

Soil damage in the subbasin includes bank erosion, sheet erosion and sediment deposition. The most significant concern relating to sedimentation is during major flood overflows. The floodwaters deposit sediment on the floodplain, causing substantial delays in planting and adding to treatment costs for nuisance weeds. Floodplain erosion in certain areas has scoured and removed rich topsoil resulting in long-term reductions in soil fertility. Sheet and gully erosion add to the sediment load of the river. Slumping can be a problem where cultivated fields or structures encroach on the rivers.

Irrigation

Although irrigation practices are increasing in North Dakota, most of the irrigation takes place outside of the Red River Basin. The subbasin is located within North Dakota's Planning Region IV and the North Central Region, and it includes the counties of Pembina, Cavalier, Towner, and Rolette. The irrigation potential within each of these counties is poor because of the limited ground water resources.

Wastewater Management

The water quality of Pembina River is reduced by high concentrations of nitrates and phosphates which enter the stream from agriculture-related non-point sources. These pollutants impair recreational, fishery, wildlife, and stock watering uses on the river (North Dakota Statewide 208 Water Quality Management Plan, 1978). The point sources, especially municipal sewer treatment facilities, appear to be adequate. Table 5 lists nine communities, and their respective treatment facilities located in the subbasin.

Hydropower

As early as 1845, the Pembina River was used for water power when a mill dam was constructed at the foot of the Pembina Escarpment. Since that time, at least ten dams have been constructed on the Pembina and Tongue rivers within the subbasin. These facilities were built primarily for flood control purposes, recreation, or additional water supply, and not for hydroelectric power generation. The existing dams and their present

Table 5

TREATMENT FACILITIES AND NEEDS OF NINE COMMUNITIES IN THE PEMBINA RIVER SUBBASIN

Community	Population Served	Design Flow (MGD)	Actual Flow (MGD)	Type Treatment	Surface Area (Total Acres)	Needs or Comments
Cavalier	1,381	0.099	0.090	Secondary	15.55	Enlarge surface area
Hamilton	110	N/A	0.007	Primary	Septic tanks	Lagoon being planned
Hannah	145	N/A	0.009	Primary	Septic tanks	Potential lagoon
Langdon	2,182	0.340	0.140	Secondary	52.4	Raise dike two feet
Neche	451	0.148	0.029	Secondary	24.0	--
Rock Lake	270	0.027	0.018	Secondary	3.6	Reline existing cell
St. John	367	0.030	0.024	Secondary	4.84	Enlarge acreage
Sarles	148	N/A	0.009	Primary	Septic tank	--
Walhalla	1,471	0.117	0.096	Secondary	18.9	Enlarge cell

N/A: Not applicable.

Source: Shewman and North Dakota State Department of Health, no date; North Dakota Statewide 208 Water Quality Management Plan, 1978.

capacities have been identified as small-scale facilities with minimal potential for hydroelectric development (U.S. Army Corps of Engineers' Institute for Water Resources). A major limiting factor in the development of hydropower in the subbasin is the lack of a sufficient amount of water; however, there are some potentials for small-scale development. Currently, generation of power is dependent on the coordinated operations of bulk power supply facilities located outside the subbasin.

Public Perception of Problems and Solutions

The public's perception of problems and solutions in the subbasin is well defined because the Corps of Engineers and the International Joint Commission have held numerous public meetings in this area over the past 15 years. The primary documents for the identification of public perception are the Plan of Survey for an interim survey for Flood Control on the Pembina River (1970), the Emergency Snagging and Clearing for Flood Control reconnaissance report (1975), the Pembina River Feasibility Report for flood control (1976), and the Draft Environmental Impact Statement-Pembina River Snagging and Clearing (1976). All of these reports were published by the St. Paul District Corps of Engineers.

Public meetings and related activities are documented beginning in June 1965 when the International Joint Commission held public meetings at Manitou and Walhalla on three alternative international plans of development. Solid support was expressed toward the recommended plan. The public also had the opportunity to express its views at a public hearing conducted by the Senate Public Works Committee at Walhalla in September 1970.

A reconnaissance of the Pembina made in December 1974 in connection with the Pembilier Reservoir project by representatives of the North Dakota State Water Commission included interviews with local interests and inspection of reaches proposed for improvement to determine existing conditions and means of reducing flood damage. The Feasibility Report published by the Corps in March 1976 lists the principal water-related needs in the lower Pembina Subbasin as flood control, improved quantity and quality of farm and municipal water supplies, additional water-based recreation, and fish and wildlife conservation.

As discussed in the flooding problems section, the construction of dikes on both sides of the international boundary is of considerable concern to area residents. By preventing natural overland flows into other watersheds, the dikes have changed existing flow conditions and worsened local flooding conditions.

Additional evidence for interest in flood control measures is contained in public hearings held in East Grand Forks in 1978 and 1979 before subcommittees of the Committee on Public Works and Transportation of the U.S. House of Representatives. From these documents, it is evident that residents of the Red River Basin consider flood control to be the primary water related need for the area and that they are interested in whatever solutions may be proposed by Federal, state, or local agencies.

IV. DESCRIPTION OF SUBBASIN RESOURCES

IV. DESCRIPTION OF SUBBASIN RESOURCES

This section of the report discusses the primary resource conditions within the subbasin that are water-related and that would be affected by a comprehensive water and related land resources plan centering on flood control measures.

Social Characteristics

The population of the subbasin decreased slightly in the decades prior to 1970. This happened because of a reduced demand for farm labor that resulted from farm mechanization and consolidation. As a consequence, people moved from the rural areas to the urban areas in search of employment. The outmigration rates in parts of the subbasin between 1960 and 1970 were as high as 27 percent. Since 1970 the outmigration has decreased, and most of the counties within the subbasin have experienced an increase in population. The population of the subbasin increased from 14,547 in 1970 to 15,564 in 1977, which was a seven percent increase. The counties of Rolette and Pembina increased naturally (more births than deaths), Towner decreased due to a high outmigration rate (6.7 percent), and Cavalier County experienced a natural increase and an inmigration rate of 5.4 percent.

The subbasin is primarily rural, with a low population density of 7.9 persons per square mile. The largest towns in the subbasin are Langdon (2,717) and Cavalier (1,887), both of which increased in population during the 1970's.

Most of the subbasin population is of Canadian background, except for the predominant Norwegian ethnic group in Towner County.

Communities in the subbasin are close-knit, as illustrated by home ownership, length of residence, and county of employment. The majority of the subbasin's population lives in Cavalier and Pembina counties, followed by Rolette and Towner counties. Most people own their homes, ranging from 65.7 percent in Rolette County to 78.2 percent in Pembina County. The 1970 populations in Rolette and Pembina counties had the lowest numbers of people living in the same residence since 1965, with 52 percent and 68 percent, respectively; but the figures rose to 82 percent

and 89 percent, respectively, living in the same county. In Cavalier and Towner counties, 71 percent and 69 percent lived in the same residence since 1965, and 91 percent of the Cavalier population and 88 percent of the Towner population lived in the same county. The number of people living and working in the same county ranged from 83 percent in Cavalier County to 92.9 percent in Rolette County.

Economic Characteristics

Employment

For the past 30 years, agricultural employment in the subbasin has been decreasing. The decline in farm jobs was primarily due to the decreasing number of farms and the increasing substitution of machinery for farm labor. Employment in trade, manufacturing, and other nonfarm activities increased slightly during the same time period, but the increases were not substantial enough to compensate for the rapid decrease in farm employment. As a result, there was a decrease in total employment.

During the 1970's most nonagricultural employment sectors continued to increase. Employment in the government sector was greatly influenced by the development of Anti-Ballistic Missile (ABM) system facilities in Cavalier and Pembina counties. Although these facilities were deactivated in 1976, employment ranged from 1,500 to nearly 4,000 between 1969 and 1976. By 1978, employment had been reduced, which created readjustment needs. The result of the fluctuations in the various employment sectors was an increase in total employment. Employment in the subbasin increased from 5,091 in 1970 to 6,692 in 1977, which was a 31 percent increase. The agricultural sector will continue to be the largest employment sector, followed in importance by trade, services, and manufacturing.

Unemployment in the subbasin averaged about seven percent during the 1970's. During the winter months when farm and construction activity is minimal, unemployment is very high. During the spring planting, unemployment decreases and continues to do so until after the fall harvesting.

Income

Total personal income for the subbasin increased from $75 million to $85 million between 1969 and 1977 (expressed in 1979 dollars). Farm

income accounts for more than half of the total personal income, and cash grain sales amount to almost three-fourths of the total farm income. Average per capita income during the same years increased from $5,140 to $5,490, which was 20 percent lower than the 1979 average income figure of $6,859 for North Dakota. Although there has been an upward trend in both total personal and per capita income, fluctuating farm prices are the primary determinants of income changes from year to year. Severe flooding, as in 1975, can also cause sharp declines in income.

Business and Industrial Activity

Agriculture

Agriculture is the main economic activity in the subbasin, and the production of small grains is the most important agricultural component. Approximately 80 percent (or 1,004,032 acres) of the subbasin's land area is under cultivation, and another seven percent is pasture. Livestock production has decreased greatly during recent years because of poor investment returns, and some pasture lands are now being converted to small grain production.

The major crops grown in the subbasin are identified in Table 6. Wheat and barley, which account for 81 percent of the harvested acreage, are the leading crops. Approximately 12 percent of the total harvested acreage is planted with sunflowers and hay. Minor acreages of potatoes, sugarbeets, oats, flax, and rye are also harvested in the subbasin.

Table 6

1978 CROP STATISTICS, PEMBINA RIVER SUBBASIN

Crop	Harvested Acres	Yield Per Acre	Total Production
Wheat	378,740	33.3	12,612,042
Barley	223,180	45.9	10,243,962

Source: Gulf South Research Institute.

Manufacturing

Of the 45 manufacturing establishments in the subbasin, approximately half support the agriculture industry. There are five fertilizer plants, five potato warehouses, several grain companies and bean warehouses, and a few manufacturers that produce farm equipment. Manufacturing employment amounts to about 10 percent of the subbasin's total employment. The manufacturing establishments are listed in Table 7, according to their Standard Industrial Classification (SIC) numbers.

Table 7

MANUFACTURING ESTABLISHMENTS, PEMBINA RIVER SUBBASIN

SIC	Description	Estimated Employment
14	Mining of Nonmetallic Minerals	36
27	Printing and Publishing	65
32	Stone, Clay, Glass, and Concrete Products	27
34	Fabricated Metal Products	10
35	Machinery, except Electrical	10
36	Electrical and Electronic Machinery	40
37	Transportation Equipment	150
38	Measuring, Analyzing, and Controlling Equipment	10
42	Motor Freight Transportation/Warehousing	120
51	Wholesale Trade-Nondurable Goods	50
54	Food Stores	100
76	Miscellaneous Repair Services	30
TOTAL		648

Source: 1978-1979 Directory of North Dakota Manufacturing.

Trade

In 1977, total trade receipts for the subbasin exceeded $132 million (expressed in 1979 dollars). Nearly 70 percent (or $90.5 million) of the receipts were wholesale trade. Retail trade and selected service receipts were $42.2 million and $4.5 million, respectively, in 1977.

Transportation Network

The subbasin is crossed from north to south by State highways 20, 1 (through Langdon), 32 (through Walhalla), and 18 (through Neche) and by U.S. 81 (through Hamilton) and Interstate 29, near the town of Pembina. Each of the state highways runs south and intersects U.S. 2, which is a direct route to Grand Forks. Highway 81 and Interstate 29 are located in the far eastern part of the subbasin, and both run south directly to the cities of Grand Forks and Fargo. The major east to west highway is State Highway 5, which runs through Langdon, Cavalier, and Hamilton and provides a connection to U.S. 81 and Interstate 29.

The Burlington Northern Railroad has seven railway lines which traverse the subbasin from north to south and provide service into the city of Grand Forks. These lines pass through most of the towns in the subbasin. The Soo Line Railroad has one rail line in the western part of the subbasin. There are municipal airports with hard-surfaced runways located in Pembina, Walhalla, and Cavalier. A few other airports in the subbasin have turf composition runways offering limited service. A pipeline carrying crude oil from western Canada to Buffalo, New York crosses the northeastern part of the subbasin, and a pipeline carrying natural gas crosses the southwestern part of the subbasin.

Land Use

Approximately 80 percent of the subbasin is cultivated, seven percent is pasture, almost six percent is forest, and 1.9 percent is urban. Only one percent of the total land area is composed of water or marsh areas.

The floodplain is an important agricultural area. Most of the land in the floodplain is under cultivation. The cities within the floodplain include Neche, Walhalla, Pembina, and Cavalier.

Environmental Characteristics

Climate

Weather information is obtainable from U.S. Weather Bureau stations at Cavalier, Langdon, and Pembina. The subbasin has a continental climate that may be classified as "cool temperate subhumid." The area is characterized

by wide variations in temperature, ample rainfall, with normal distribution for crops, and moderate snowfall. The average annual temperature in the subbasin is approximately 36°F, with extremes ranging from 112°F to -54°F. The average date of the last frost is May 25 and that of the first frost, September 17. The average length of the growing season is 115 days. On clear days the sun will shine for more than 15 hours from the middle of May to the end of July. These long hours of sunshine make it possible to grow many crops in what appears to be a comparatively short growing season. Annual precipitation for the basin is only 18 inches. Due to the degree of precipitation in the area, the amount of moisture that can be stored in the soil is of great importance for plant growth. Snowfall over the basin averages about 38 inches per year, which is equivalent to about 21 percent of the average annual precipitation.

Geology

The subbasin lies within the Western Lake section of the Central Lowland Province of the Interior Plains physiographic division. Bedrock formations underlying the subbasin include deposits of the ordovician, jurassic, cretaceous, and tertiary periods. The eastern portion of the subbasin on the valley plain is composed of ordovician and jurassic undifferentiated shale and sandstone. Cretaceous deposits underlie the majority of the subbasin and are represented in overlying bands from east to west by the Dakota Group, the Colorado Group, Pierre Shale, Fox Hills Sandstone, and the Hill Creek Formation. There is a small section in the extreme western corner of the subbasin composed of calcareous shale, lignite, sandstones, marine sands, clay and shales of the Fort Union Formation.

There are three physiographic sections known as the Red River Valley Plain, Pembina Delta, and Drift Prairie Plateau formed by glacial activity. The valley plain near the Red River is basically level land marked by a series of low, elongated sandy ridges trending northwest to southeast. Lacustrine silt and clay underlain by glacial till characterizes this portion of the subbasin. The western boundary of the valley plain is formed by a steep escarpment trending generally from the northwest to southwest that crests approximately 500 feet above the plain.

The Pembina Delta is a small area lying west of the escarpment. The delta was created by the Pembina River discharging directly into Lake Agassiz. Silty sand and gravel is underlain by till in this area. Most of the subbasin lies in the drift prairie plateau, which is characterized by undulating, poorly drained surface areas. Morainic hills, ridges, undrained depressions, lakes, sloughs, and swamps are common in this region. The entire plateau is mantled with clayey glacial till varying from 20 to 60 feet in thickness. The Turtle Mountain Range, rising 400 feet above the plain, borders the extreme western portion of the subbasin.

Biology

The subbasin has been described as the junction for three major biomes: the Aspen Parkland (Coniferous Forest-Grassland Ecotone) from the north, the Tall Grass Prairie from the west and south, and the Oak Parkland (Deciduous Forest-Grass Ecotone) and Eastern Deciduous Forest from the east (U.S. Army Corps of Engineers, 1977a). The upper and central portions of the subbasin are heavily wooded in comparison to most of North Dakota, while the eastern portion is intensively cultivated. Woodlands in the eastern part are generally confined to the floodplains in the form of a gallery forest. Four major natural ecosystems are found in the Pembina River Valley:

1. Bottomland hardwood forests. This community extends into the valley along the floodplain and on moist, north-facing slopes. Dominant trees in the floodplain include American elm, cottonwood, boxelder, willow and green ash. Associates consist of some aspen, basswood, paper birch, bur oak, and balsam poplar. The shrub strata is poorly-developed, with chokecherry, red-osier dogwood, and wolfberry predominant. The herbaceous layer is composed mainly of wood nettle, smooth bromegrass, and tall coneflower. Dense stands of deciduous trees may occur on north and east-facing slopes, containing species like those described for the floodplain but without cottonwood and willow. Bur oak is found occasionally, and the shrub layer is well-developed.
2. Upland mixed hardwood forest. This community also occurs on moist slopes forming fairly dense stands composed of basswood, aspen, green ash and paper birch. The shrub layer is usually well developed with hazel and chokecherry. The herbaceous layer is poorly developed and generally comprised of wild sasparilla, wild ginger, poison ivy, and sedges.

3. Oak savanna woodland. Found on the dry sites of the eastern part of the subbasin, this community consists of bur oak and other upland oaks with some aspen, boxelder, and ash. The overstory strata is generally 15 to 20 feet in height, with small wolfberry, serviceberry, and chokecherry in the shrub layer. In certain areas a chokecherry-hazed thicket exists with an understory of Canada anemone, goldenrod, and quackgrass. Much of the woodlands and grassland found in this association have been converted to pasture or cropland.

4. Tall Grass Prairie. Most of this community has been eliminated or altered through agricultural development. Natural vegetation consists of grasses such as big and little bluestem, Indian grass, prairie dropseed, and a number of forbs. Heavily disturbed areas now support species such as white and yellow sweet clover, common sunflower, hedge nettle and wild buckwheat. Kentucky bluegrass, smooth brome and bushy areas of chokecherry, wolfberry, and red osier dogwood occur in areas of less disturbance.

The wetlands of the subbasin include the Pembina River and its tributaries and the associated slackwater areas. A deep freshwater marsh is found at Rush Lake, and marsh fringes are found around other waterbodies such as Swan, Loren, Louise, Rock, and Bone lakes. Grass Lake is also a marsh area. Wetland types which are known to occur in Pembina, Cavalier, Towner, and Rolette counties consist of the following: Type 1--seasonally flooded basins or flats; Type 3--shallow fresh marshes; Type 4--deep fresh marshes; Type 5--open fresh water; Type 10--inland saline marshes; and Type 11--inland open saline waters (U.S. Fish and Wildlife Service, 1979; U.S. Army Corps of Engineers, 1977a).

Habitats of importance to wildlife in the subbasin include the extensive woodlands and the remaining wetlands and grasslands. The woodlands and brushy areas provide habitat for breeding, reproduction, feeding, loafing, and escape cover for many resident and migratory wildlife species. They also furnish a travel corridor for animals moving from the more pristine environs of the western part to the developed areas of the eastern portion. Because of the large woodland areas of the upper basin, deer populations are very good, as are the densities of other forest-oriented game animals such as the ruffed grouse. Wolves, black bear, bobcat and Canada lynx, animals with low to very low population levels in the state and region,

are occassionally reported in the upper basin. Forests afford breeding and nesting areas for birds, ranked second only to wetlands in breeding bird population densities. Forests contain a greater variety of wildlife species than any other major habitat type; thus, there is a very real need to protect the woodlands of the subbasin. Wetlands furnish breeding, nesting, feeding, and resting areas for waterfowl; breeding and rearing habitat for big and small game, furbearers, and other wildlife such as passerine and wading birds; spawning and nursery areas for fishes and aquatic invertebrates; and a high-yield food source for many resident species. As indicated above, they rank first in breeding bird densities, with average populations reported at 337.0 pairs/km^2. Native grasslands or prairie, when found in combination with wetland complexes, form a dynamic and varied ecosystem which supports diverse and abundant populations of birds, mammals, invertebrates, and plants. Average breeding bird densities of 142.7 pairs/km^2 have been recorded in this highly productive community. Like the woodlands, both the remaining wetlands and prairies of the subbasin need to be protected, conserved, and enhanced wherever possible (U.S. Fish and Wildlife Service 1979, 1980; U.S. Army Corps of Engineers, 1977a).

The most important big game animal in the subbasin is the white-tailed deer, with population densities varying from <0.5- 1.5 deer/square mile. Greatest abundance occurs along the Red River, Tongue and Pembina rivers to eastern Cavalier County, and in the upper part of the subbasin. High populations of moose, <0.15 moose/sq. mile, are found in western Pembina and eastern Cavalier counties, while the remainder of the region is low with <0.05 moose/sq. mile. Waterfowl production is low in the Red River Valley area at <4.0 breeding pairs/sq. mile, and medium to high in the western portion with 4.0-9.0 pairs/sq. mile. The most important species in the region include the mallard, blue-winged teal, pintail, gadwall, northern shoveler, green-winged teal, American wigeon, and redhead. Rush Lake receives heavy use by waterfowl. Of significance is the value of the subbasin to wood ducks; the heavily wooded areas along the river support one of the few significant natural breeding populations in the state (data from North Dakota Game and Fish Department in U.S. Fish and Wildlife Service, 1979).

The Hungarian partridge is the principal upland game bird. From the eastern one-quarter of Cavalier County east to the Red River, densities are high at 32-60 birds/1,000 miles of rural mail carrier route; medium densities are encountered in the remainder of the subbasin with 12-31 birds/1,000 miles. Shays-tailed grouse are also hunted with populations considered low at <3.0 birds/sq. mile. A few pheasants are harvested, but densities are also low at <1.0 hens/sq. mile. Stocking programs are carried out to build the pheasant population, as well as to provide a huntable population of wild turkeys in the subbasin. Common furbearers are the raccoon, beaver, mink, muskrat, skunk, weasel, and red fox. Population densities for the red fox vary from 5.0-13.0 families/township. The principal small game mammals of the subbasin are the cottontail and fox squirrel (data from North Dakota Game and Fish Department in U.S. Fish and Wildlife Service, 1979). Table 8 gives harvest data for many of the game and furbearing species mentioned above in Pembina County from 1970-1975.

Approximatley 273 species of avians have been reported from the northeastern region of North Dakota, which includes Pembina, Grand Forks, Nelson and Walsh counties. A total of 168 species have been identified as breeding birds; characteristic species include the horned lark in croplands, bobolink in grasslands, mourning dove in shelterbelts, eastern kingbird in thickets, red-winged blackbird in wetlands, and the red-tailed hawk in the forest community. About 31 nongame mammals have been identified from the area and include the short-tailed shrew, red bat, thirteen-lined ground squirrel, northern pocket gopher, Gapper's red-backed vole, and house mouse. Amphibians are represented by nine species and reptiles by seven species. Typical herpetofauna include the tiger salamander, Great Pelaris toad, leopard frog, and red-sided garter snake. The Pembina River also has a substantial snapping turtle population (Willis, 1977; Steward, 1975; U.S. Army Corps of Engineers, 1977b).

The following reaches of streams within the subbasin have been determined by the North Dakota Game and Fish Department to provide a substantial fishery:

Table 8

HARVEST DATA FOR GAME AND FURBEARING ANIMALS
IN PEMBINA COUNTY, PEMBINA RIVER SUBBASIN

Species	Number Harvested					
	1970	1971	1972	1973	1974	1975
Redfox (trapped and hunted)	82	639	516	1,396	632	732
Coyote (trapped and hunted)	--	--	--	--	--	7
Sharp-tailed grouse	558	1,249	454	473	241	619
Ring-necked pheasant	0	0	0	0	0	35
Cottontail	614	674	587	939	175	562
White-tailed deer	298	567	465	488	300	294
Hungarian partridge	907	2,290	1,508	4,575	960	625
Fox squirrel	1,120	507	2,058	1,798	1,470	1,834

Source: North Dakota Game and Fish Department in U. S. Fish and Wildlife Service, 1979.

1. Pembina River from Red River to Walhalla
2. Tongue River from Pembina River to Cavalier
3. Little South Pembina River from Pembina River to Mt. Carmel Dam

This designation has been given to these streams because they provide a moderate forage fish production and a limited sport fishery. Other criteria considered included channelization, water quality degradation caused by agricultural runoff and municipal effluents, and intermittent flows. The upstream reaches of these rivers have been classified as critical and contain the highest valued fishery resource. Justifications for this evaluation include moderate to excellent sport fishery, moderate forage fish production, high recreational and aesthetic values, highly valued wildlife habitat, good water quality, and water supply for municipalities. The Little North Pembina River is also within this critical class (U.S. Fish and Wildlife Service and North Dakota Game and Fish Department, 1978).

Northern pike, walleye, sauger, and channel catfish are game fish common to the Pembina River and its tributaries. The Little South Pembina reach from the headwaters to Mt. Carmel Dam has a critical value for serving as a water supply for Mt. Carmel Dam. In 1978 Mt. Carmel Dam supported an excellent trout fishery. However, due to increased eutrophication from agricultural runoff, Mt. Carmel Dam presently only supports a northern pike and walleye sports fishery. Rough and forage fish which frequent the Pembina River system include bigmouth shiners, common shiners, sand shiners, blacknose dace, white suckers, bullheads, brook sticklebacks, Johnny darters, and blacksided darters. The trout-perch, which is considered rare in North Dakota, was reported at several sampling stations by Copes and Tubb (1966).

Several natural and artifical lakes occur within the subbasin. Some of these have been stocked with rainbow and brown trout and support good populations of sauger and northern pike. Most, however, are subject to severe winter and summer kill due to oxygen depletions. Rough and forage fish commonly found in the lakes include central mudminnow, northern red belly dace, common shiner, fathead minnow, creek chub, white sucker, and Johnny darter (U.S. Army Corps of Engineers, 1977b; International Pembina River Engineering Board, 1964; Copes and Tubb, 1966).

Very little information exists on the aquatic invertebrates of the Pembina River. The Corps of Engineers (1977b) reported a few waterboatmen, waterstriders, and a very limited population of periphyton during a cursory inspection of the confluence of the Little North Pembina River and the Pembina River. Cvancara (1970) reported six mussel species that were represented by live specimens. These were Lasmigona compressa, Lasmigona complanta, Anodonta grandis, Anodontoides ferussacianus, Strophitus rugosus, and Lampsilis siliquoidea.

Water Supply

Sufficient quantities of groundwater for domestic and farm use are available throughout nearly all of the subbasin; however, aquifers capable of supplying large, sustained yields are rare. In the Red River Valley, shallow wells can be developed for limited use in a surficial bed of clay and silt. The deeper bedrock units can supply water under artesian pressure, but the water is usually too saline for most uses. The deposits of the Pembina River from about two miles southwest of Walhalla to 10 miles downstream form the best known aquifer in the area. This aquifer supplies water of good quality for the city of Walhalla. Annual water usage for Wahalla is approximately 38,325,000 gallons. Langdon and Cavalier use river water as a source of supply, with approximate annual usages of 128,115,000 and 124,830,000 gallons, respectively. Shallow, large diameter low-flow wells tapping deposits of glacial drift typify the majority of the existing farm wells in the subbasin. Although this region has fertile soils, manufacturing and other industries dependent on agricultural products for raw materials have been reluctant to locate because of the unfavorable water supply conditions.

Water Quality

The Pembina River and its main tributary, Tongue River, have been classified as Class IA and Class II streams, respectively. A stream classified as such is supposed to permit progration of fish and wildlife, body contact recreation, irrigation, and stock watering. Class II streams require additional treatment of effluent other than required for Class I streams (Shewman and North Dakota State Department of Health, no date).

Table 9 presents water quality data from two stations on the Pembina River and one station from the Little South Pembina River. The data presented in the table indicates that the phosphate standard is almost consistently violated. Additionally, sulfates, nitrates, TDS, fecal coliforms, dissolved oxygen, and pH are sometimes reported in extreme conditions and occassionally are in violation of the standards. Many of the major pesticides (such as DDT, lindane, heptachlor, toxaphene, 2,4-D, and chlordane) were tested for during the same samplings at these stations. No pesticides were discovered from any of the samples (U.S. Geological Survey, 1979).

Table 9

SURFACE WATER QUALITY DATA FROM THREE RECORDING STATIONS ON THE PEMBINA RIVER, OCTOBER, 1977 TO SEPTEMBER, 1978

Parameter	Standard[1]	Vang		Walhalla[2]		Walhalla	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Stream Flow (CFS)	--	0.01	1,500	0.28	1,190	0.11	3,360
pH (Standard Units)	7-8.5	7.2	8.5	7.4	8.3	7.1	8.3
Temperature (°C)	31	0.0	25.5	0.0	22.5	0.0	25.0
Dissolved Oxygen (D.O.)	5.0 (Min)	0.5	12.6	7.4	13.2	6.4	13.0
Fecal Coliform (#/100 ml)	200	11	3,100	33	1,200	<1	280
Hardness ($CACO_3$)	--	640	120	120	390	220	490
Sulfate	--	280	82	74	250	110	260
Chloride	175	4.4	23	5.1	27	7.7	20
Fluoride	--	0.2	0.4	0.2	0.6	0.1	0.4
Total Dissolved Solids (TDS)	1,000	247	958	249	636	402	736
Nitrates (N)	4.0	0.22	5.4	0.00	3.6	0.01	3.0
Phosphates (P)	0.1	0.09	0.74	0.07	0.28	0.04	0.21
Iron (mg/l)	--	30	220	10	110	10	130

[1]From Shewman and North Dakota State Department of Health, No Date.

[2]Monitoring station located on Little South Pembina River near Walhalla.

Source: U. S. Geological Survey, 1979.

The Upper Mississippi River Basin Commission (1977) considered the groundwater supplies in the subbasin to be very limited. Presently, Rock Lake and Walhalla are the only municipalities that use groundwater exclusively for their public supply. Cavalier uses groundwater supplies for its secondary system and the Tongue River for its primary system. The aquifers

within the subbasin produce hard water that contains iron, sulfates, and dissolved solids in concentrations that exceed the accepted drinking water standards (Red-Rainy Rivers Basin Commission, 1972; Upper Mississippi River Basin Commission, 1977). Table 10 presents water quality data from two communities that utilize groundwater sources for their public supplies.

Table 10

GROUNDWATER QUALITY FROM TWO COMMUNITIES WITHIN THE PEMBINA RIVER SUBBASIN

Parameter	Cavalier	Walhalla
Total Dissolved Solids (TDS)	228	775
Hardness ($CaCO_3$)	65	430
Iron	0.0	0.4
Manganese	0.0	0.0
pH (Standard Units)	9.4	7.6
Sodium	22	46
Fluoride	0.9	0.6
Chloride	11	1
Sulfates	125	165
Nitrates	0	0

Note: Unless otherwise stated, all units of measure are in milligrams per liter (mg/l).

Source: North Dakota State Department of Health, 1964.

Aesthetics

The level terrain in the eastern section of the subbasin is broken dramatically by the Pembina Escarpment that rises 500 feet above the plain. The Turtle Mountains in the extreme western portion of the subbasin rise 400 feet. The Little North Pembina Gorge and Tongue River Gorge also provide areas of landscape diversity and aesthetic appeal. Areas of particular interest in the subbasin include Tetrault State Forest (429 acres), near Walhalla, Icelandic State Park (220 acres); and the International Peace Gardens (2,339 acres) near Dunseith. The Peace Gardens are on the Canadian border and attract an estimated 300,000 visitors annually.

Cultural Elements

Previous archeological-historical reconnaissances in the eastern part of the subbasin have indicated relatively few recorded archeological sites (Schneider, 1976; Ames, 1975). Here, as elsewhere in the Red River Valley, archeological resources are of a relatively late cultural context. Glacial Lake Agassiz inundated parts of the subbasin, and human occupation was not feasible until about 7000 B.C. For sometime after the retreat of the glacial lake, the lacustrine plain remained poorly drained, somewhat swampy, and relatively unappealing to early prehistoric inhabitants.

Glacial beach ridges (strandlines) here, as throughout the Red River Valley, are often significant geological features and highly probable locations for occupation and mound sites (Johnson, 1962:126; Saylor, 1975:251). Other probable locations for archeological-historical sites include lake shores and stream banks.

The Pembina River region has played a significant role in the history of the Red River Valley. Historically, the region was inhabited by members of the Plains Chippewa, Cree, Assiniboine, and other nomadic Plains Indians. The earliest recorded European exploration of the Pembina region was associated with the development of the fur trade by a French Canadian (WPA, 1950:39). The subbasin soon became the scene of fierce competition and confrontation between the Hudson's Bay Company and the North West Company in a struggle for control of the fur trade.

By the late 18th and early 19th centuries, the North West Company and Hudson's Bay Company had established competing trading posts. The junction of the Red and Pembina rivers became the focal point for the control of trade. The Indians were soon drawn into the economic competition. Due to the influence of the fur trade, the Chippewa Indians had expanded as far west as the Turtle Mountains by 1820 (Hewes, 1948:49-50).

The Metis, a distinctive ethnic group of Indian-European heritage, were most active in the fur trade of the area. Most of the Metis were buffalo hunters for part of the year, but they also sold supplies (pemmican) to American traders, and they were also active in the Red River cart trade with St. Paul (Robinson, 1966:67-75). The Metis population in the Pembina area was substantial until the decline of the buffalo promoted it to move westward.

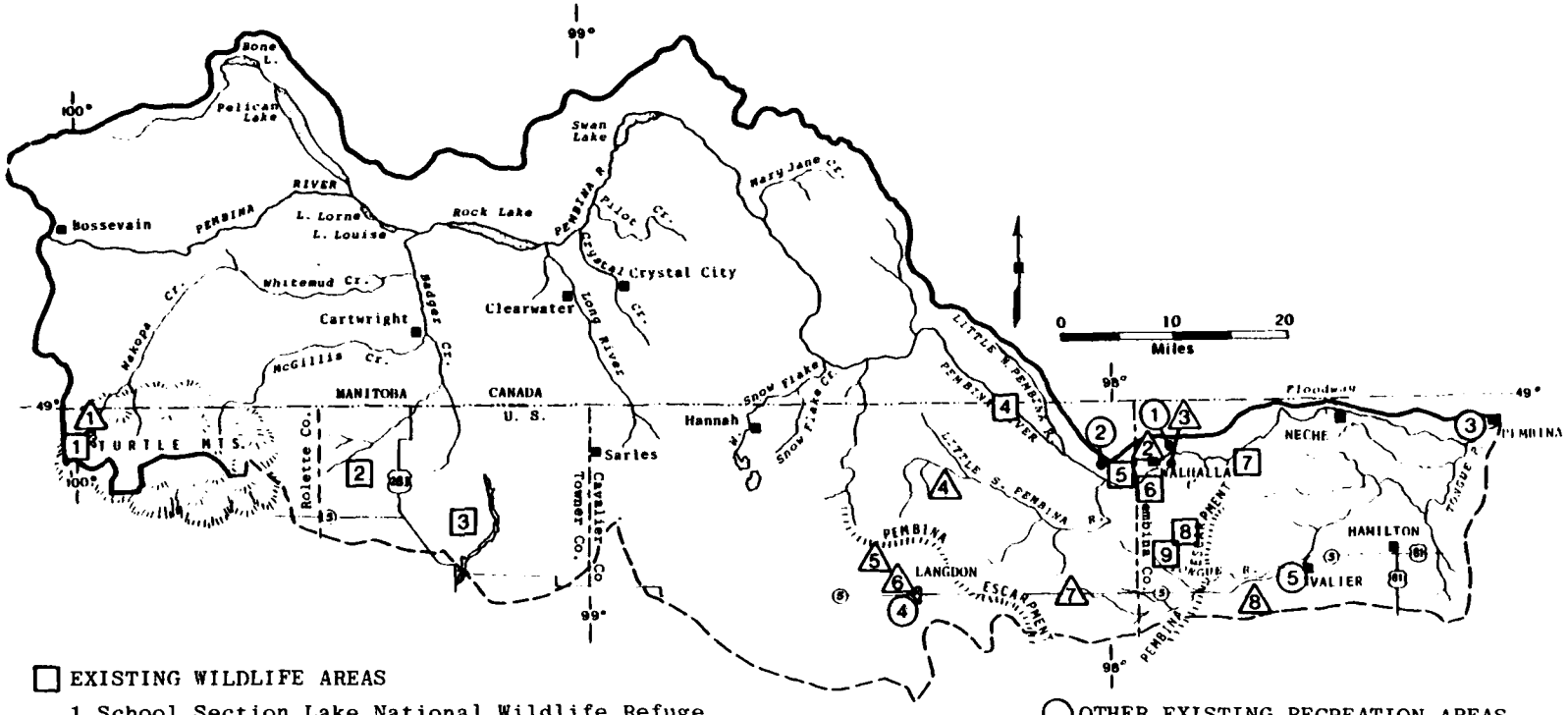
The fur trade had still other consequences for the Pembina region--it retarded the growth of agriculture as traders and trappers resisted organized settlement. The first agricultural settlement in the Red River Valley was established here in 1812 by a Scotsman named Lord Selkirk (Franke in Schneider, 1976:6). The original colony was established in Manitoba, but to avoid starvation, the colonists lived part of the year at the confluence of the Red and Pembina rivers, near the present town of Pembina, North Dakota (Robinson, 1966:64-66). Buffalo meat staved off starvation until agriculture was finally established. Between 1871 and 1889, the agricultural development of the Pembina area was well established by American settlers (Franke in Schneider, 1976:8).

The subbasin is potentially rich in historical sites. Most of those noted are at the confluence of the Red and Pembina rivers and along the Pembina River itself. Franke (in Schneider, 1976:8-11) noted 15 potential historical sites along the Pembina River between the towns of Neche and Pembina, North Dakota. Only one, however, is listed on the National Register of Historic Places. Surface surveys would be necessary to verify and assess the significance of cultural resources inventoried from historic documents. The possible association of cultural resources with major streams could have a significant impact on the implementation of flood control measures.

Recreational Resources

There are significant recreational resources within the subbasin, represented by a total of approximately 12,118 acres designated as recreational sites. The major recreational assets of the subbasin include Icelandic State Park (220 acres) and Tetrault State Forest (429 acres), which provide residents of the subbasin with a variety of recreational opportunities. Both of these areas and other recreational sites larger than 15 acres are illustrated in Figure III. An inventory of facilities at these sites which account for 99 percent of recreational acreage in the subbasin is presented in Appendix B of this report.

Hunting is a popular recreational activity in the subbasin. There are seven wildlife management areas in the subbasin west of the escarpment, including two National Wildlife Refuges in Rolette and Towner counties.



☐ EXISTING WILDLIFE AREAS

1 School Section Lake National Wildlife Refuge
2 Armourdale Dam WMA
3 Rock Lake National Wildlife Refuge
4 Pembina Hills WMA
5 Tetrault State Forest(a)
6 Tetrault State Forest(b)
7 Martineau WMA
8 Clifford WMA
9 Tongue River WMA

△ EXISTING RECREATIONAL AREAS

1 International Peace Gardens
2 Frost Fire Mountain Ski Resort
3 Walhalla Park
4 Mt. Carmel Dam
5 Pembina Hills Ski Way
6 Langdon Park
7 Senator Young Dam
8 Icelandic State Park

○ OTHER EXISTING RECREATION AREAS

1 Walhalla Country Club
2 Pembina Golf Course
3 Walhalla Golf Course
4 Langdon Golf Course
5 Cavalier Country Club

Source: Gulf South Research Institute.

Figure III. RECREATIONAL RESOURCES

A significant wildlife population exists in the subbasin, including white-tailed deer, moose, elk, grouse, partridge, and wild turkeys. Beaver and mink are the most important furbearers found within the subbasin.

Upstream reaches of the Pembina, Tongue, and Little South Pembina rivers provide excellent sport fishery, including northern pike, walleye, sauger, and channel catfish. Trout fishing is popular in the Little South Pembina River. The Pembina River has been identified for possible inclusion in the North Dakota system of wild, scenic, and recreation rivers.

It should be noted that the International Peace Garden is located in Rolette County and constitutes an important recreational asset to residents of the western portion of the subbasin. Improvements for Icelandic State Park and the multi-purpose project at Pembilier Dam, which includes plans for recreational development, are the only proposed sites identified in the subbasin. In addition, Johnson, Goschke, and Mount Carmel dams and Renwick Reservoir have been constructed in the area and serve as important bases of water and water-related recreational activity.

Significant Environmental Elements

Social

The towns of Pembina, Neche, and Walhalla are the urban areas most seriously affected by flooding problems. Several Corps of Engineer and Soil Conservation projects have been implemented which have alleviated flooding to some extent, but the above mentioned towns are still experiencing extensive problems. Damages caused to the towns by flooding include costs to repair residences, commercial establishments, transportation arteries, and utility lines. Damages to municipal water supplies or sewage systems may present health hazards.

The towns in the subbasin function primarily as agricultural service centers. As such, they suffer indirect economic losses because of the losses incurred by farmers as a result of flooding, including delays in planting, damages to mature crops, farm structures and equipment, and the time needed to remove debris. It should be noted, however, that several flood control projects in the subbasin have been terminated because of lack of local support.

Cultural

Archeological resources in much of the subbasin might be expected to be of a relatively late cultural context because of geological conditions discussed previously. The subbasin has played a significant role in the history of the Red River Valley because early trade and agricultural settlement centered here. To date, only one historical site is listed on the National Register of Historic Places; but, as mentioned earlier, at least 15 have been tentatively identified from literary sources. The known and expected proximity of cultural resources to the Pembina River might be expected to affect the implementation of some flood control alternatives. These impacts are impossible to predict fully without a complete assessment of cultural resources in the subbasin.

Soils

The subbasin is divided into three district sections, with the Drift Prairie Plateau in the west and the Red River Valley in the east. A rugged strip of terrain, the Pembina Escarpment, separates the two plains regions. The Drift Prairie Plateau is mantled with glacial till composed of clays, sands, gravels and boulders. This region is made up of rolling undulating uplands, interspersed with flat areas, and the Pembina River Valley. Places in the uplands consist of irregular hills and depressions or potholes which are poorly drained or lie in undrained subbasins.

The area between the escarpment and the Red River of the North is flat with a gentle slope to the east. The Red River Valley soils consist of upper alluvial sandy silts and lower lacustrine clays overlying the deeply buried glacial till. Because of its fertile soil, this portion of the study area is regarded as one of the best agricultural areas. The silty clay soils are nearly all used for cultivated crops, but areas along streams are usually wooded or used for pasture.

Water

Only one percent of the total land area of the subbasin is occupied by water. This is one of the lowest percentages of water in the Red River Basin. However, streams such as the Tongue, Pembina, and Little South Pembina provide the subbasin with abundant fish populations which are very important to the recreational pursuits of trout and sport fishing.

Woodlands

The woodlands and brushy areas of the subbasin are considered significant because of their value as wildlife habitats, and, as explained in the Problems and Needs section, compose one of the most important areas of natural woodlands remaining in the State of North Dakota. In addition to their value as habitats for wildlife, they are important for wildlife-oriented outdoor recreation, and for their aesthetic appeal. It was further recognized under Problems and Needs that, during the period 1958-1967, clearing of private lands averaged more than three percent in Pembina and Cavalier counties, where most of these woodlands occur. There is a very real need to protect these habitats, as well as the floodplain forests in the eastern portion of the subbasin.

Wetlands

The wetlands of the subbasin are significant because of their many beneficial uses and values as habitats for flora and faunal development, waterfowl production, water storage during spring runoff and periods of extreme precipitation, groundwater recharge, sediment traps, and nutrient traps (Cernohous, 1979; U.S. Fish and Wildlife Service, 1979; E.O. 11990, dated 24 May 1977). They are also significant because of the limited amount remaining, as compared to their original number and acreage.

Table 11 gives the number and areal extent of wetlands in the counties included by the subbasin from the 1964 inventory conducted by the U.S. Fish and Wildlife Service. The 1964 data represents a 25 percent sampling. All numbers except for Type 1 have been multiplied by four to give 100 percent values for numbers and acreages of wetlands. Type 1 wetlands were not measured in the 1964 survey; however, previous studies have indicated that they comprise about 10-15 percent to total wetland acres and 60 percent of total wetland numbers in the Prairie Pothole Region. This information was used to calculate Type 1 estimates. The 1964 data (expanded to 100 percent) is a conservative estimate. No acreage figures are available for wetlands drained and converted to cropland, but most have been drained in eastern North Dakota. Current annual wetland drainage estimates are thought to be less than two percent of the remaining wetland base, except in isolated areas where it may be higher (U.S. Fish and Wildlife Service, 1979).

Table 11

1964 WETLAND INVENTORY DATA FOR THE FOUR COUNTIES INCLUDED BY THE PEMBINA RIVER SUBBASIN

	WETLAND TYPES[a]													
	1		3		4		5		10		11		TOTAL	
County	Number[b]	Acres[c]	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Pembina	14	23	19	75	4	77	0	0	0	0	0	0	37	175
Cavalier	10,095	5,989	16,525	36,955	292	2,940	8	33	0	0	0	0	26,920	45,917
Towner	7,963	5,637	12,765	29,315	439	5,025	28	2,896	28	182	12	164	21,235	43,219
Rolette	7,088	5,889	9,692	14,610	1,655	11,104	434	11,171	4	744	28	1,632	18,901	45,150

[a]Type 1 - Seasonally flooded basins and flats.
Type 3 - Shallow fresh marshes.
Type 4 - Deep fresh marshes.
Type 5 - Open fresh water.
Type 10 - Inland saline marshes.
Type 11 - Inland open saline waters.

[b]Calculated at 60 percent of total wetland numbers.

[c]Calculated at 15 percent of total wetland areas.

Source: U. S. Fish and Wildlife Service, 1979.

Waterfowl Production Areas

Waterfowl production areas (WPAs) are significant because they provide favorable nesting habitat for waterfowl. Additionally, these areas are heavily utilized by upland birds and other animals. WPAs are purchased or leased by the Federal government with funds borrowed against revenue from the sale of Duck Stamps. Public hunting and trapping is allowed on the WPA's in accordance with Federal and state regulations. Figure IV shows the approximate locations of 11 WPAs established in the subbasin. Table 12 presents total acreage figures for all the WPAs and wetland easement areas of the counties included in the subbasin. The wetland easement areas are included since they, too, provide valuable habitat for a variety of species. Both area types are managed by the U.S. Fish and Wildlife Service.

Table 12

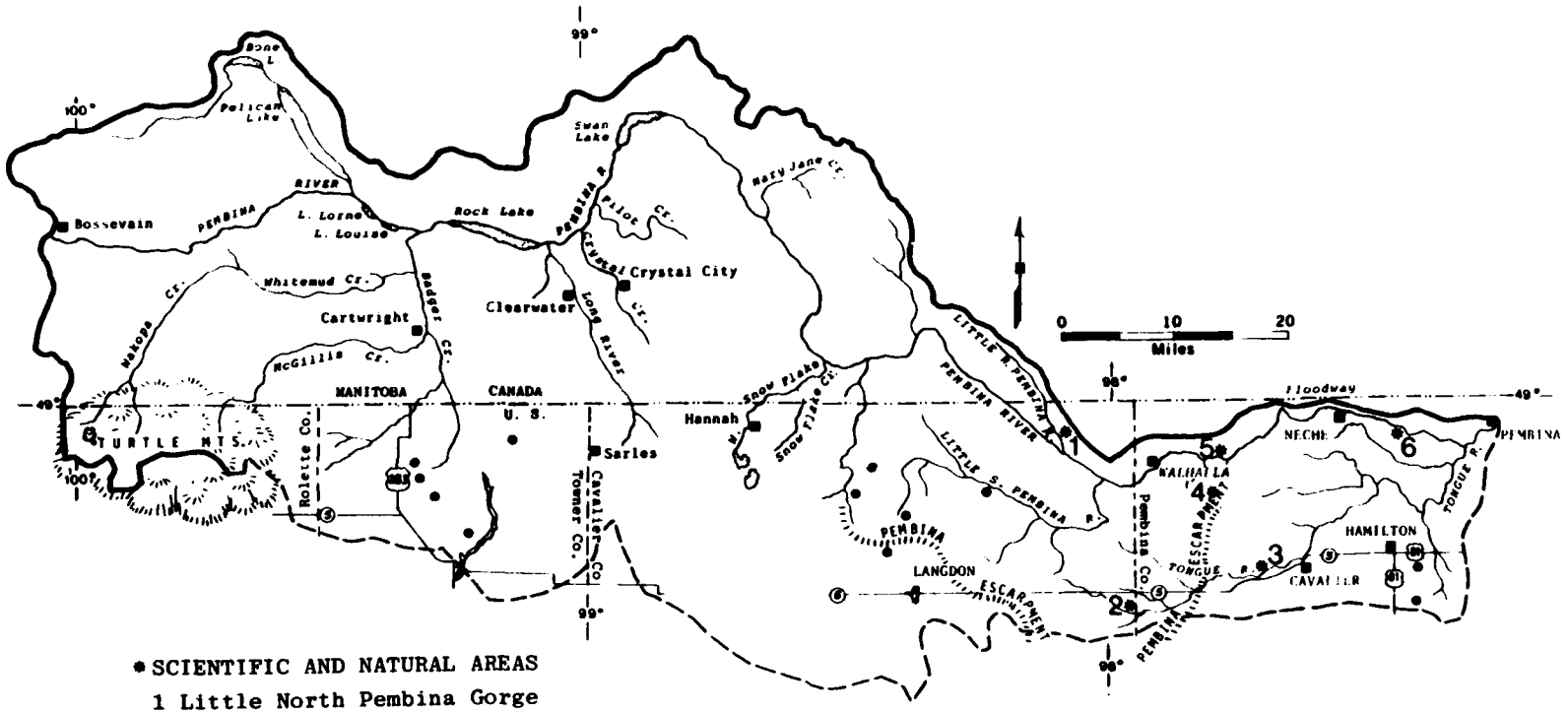
WATERFOWL PRODUCTION AREAS (WPAs) AND WETLAND EASEMENT AREAS LOCATED WITHIN THE COUNTIES INCLUDED IN THE PEMBINA RIVER SUBBASIN

County	WPAs (Acres)	Wetland Easement Areas (Acres)	Total (Acres)
Cavalier	9,461	13,900	23,361
Pembina	2,142	139	2,281
Rolette	4,914	19,419	24,333
Towner	2,467	24,211	26,678
TOTAL	18,984	57,669	76,653

Source: U. S. Fish and Wildlife Service Fee and Easement Interests in Real Property, 1979.

Wildlife Management Areas

A total of seven wildlife management areas are found within the subbasin. A list of these areas and their acreages and locations were presented in the existing conditions section for recreation. These areas are considered significant because of the opportunities provided for outdoor recreation and protection and management given to biological resources within their confines.



- ● SCIENTIFIC AND NATURAL AREAS
  - 1 Little North Pembina Gorge
  - 2 Tongue River Gorge
  - 3 Arka Grove
  - 4 Black Ash Woods
  - 5 St.Joseph Woods
  - 6 Mc.Larty Grove
- ● WATERFOWL PRODUCTION AREAS (Fee Tracts)

Source: State Comprehensive Outdoor Recreation Plan, 1975; Kantrud, 1973.

Figure IV. WATERFOWL PRODUCTION AREAS AND SCIENTIFIC AND NATURAL AREAS WITHIN THE PEMBINA RIVER SUBBASIN

Threatened or Endangered Species

Several animal species that are considered to be threatened or endangered in North Dakota have been reported from the subbasin. Endangered mammal species that have been recorded include the American elk, timber wolf, fisher, black bear, and cougar. All five of these species have declined in population, mainly because of pressure brought on by activities such as hunting and trapping for bounties, illegal hunting, and encroachment into their natural habitats (McKenna and Seabloom, 1979).

Four endangered or threatened bird species are known or presumed to occur within the subbasin: (1) bald eagle, (2) osprey, (3) American peregrine falcon, and (4) white-winged scoter. The white-winged scoter has been reported to breed in the Turtle Mountains within Rolette County. Egg collection by ornithologists, hunting pressure, and degradation of water quality has caused the gradual decline in the scoter's population. No recent breeding records of the other three birds have been reported from the subbasin, but the subbasin is included within the migratory paths of all three. The decline of these birds is a direct result of human activity, especially pesticide pollution such as DDT and its derivatives (McKenna and Seabloom, 1979).

The lake sturgeon, north redbelly dace, and trout-perch are the fish species found in the subbasin that are considered to be threatened or endangered. The lake sturgeon's decline has been influenced by overharvest, disruption of habitat and pollution. The northern redbelly dace frequents springs or areas near springs where there is plentiful vegetation and some sand or gravel. The destruction or disturbance of these spring habitats have caused the decline in the redbellys dace's population (McKenna and Seabloom, 1979). The trout-perch's populations have been reduced mainly because of the construction of reservoirs and other such impoundments (U.S. Fish and Wildlife Service, 1979).

Other Important Species

The other important animal species found in the subbasin are considered peripheral species. One mammal species, the Canada lynx, has been reported from the area. Five bird species are listed as peripheral: (1) pileated

woodpecker, (2) chestnut sided warbler, (3) northern waterthrush, (4) mourning warbler, and (5) white throated sparrow. No reptile or amphibian is considered to be threatened or endangered, but one amphibian, the gray tree frog, is listed as a peripheral species that occurs in the subbasin. The central mudminnow, river shiner, blackchin shiner, and fine scale dace are fishes that have been reported from streams included in the Pembina River Subbasin and that are listed as peripheral species. The only confirmed report in Minnesota of the fine scale dace was from the Tongue River (McKenna and Seabloom, 1979).

Rare and Unique Plants

A total of 23 plant species that occur in the subbasin are listed by Barker et al. (no date) as being rare or unique species. To be included in Barker's annotated list, a species must be reported in no more than three counties. If, within these three (or fewer) counties, only a few individuals are recorded, then the species is considered to be rare. If there are many individuals at the recorded stations, then the species is considered to be unique (Barker et al., no date). Table 13 lists the 23 species reported from the subbasin.

Natural Areas

Kantrud (1973) listed 11 natural areas that are located within the subbasin. Two of these (the Little North Pembina Gorge and the Tongue River Gorge) are located in the eastern portion of Cavalier County. These two sites offer a scenic overview, as well as habitats for wildlife such as the scarlet tanager, lynx, northern waterthrush, ovenbird, and moose. The other nine natural areas are scattered throughout Pembina County: (1) Black Ash Woods, (2) St. Joseph Woods, (3) McLarty Grove, (4) Akra Grove, (5) Tongue River Game Management Area (GMA), (6) Clifford GMA, (7) Icelandic State Park, (8) Foxen Grove, and (9) Tetrault State Forest. All of these sites are comprised of bottomland hardwoods that have a high biological productivity. Species known or presumed to occur in these areas include lynx, timber wolf, false spikenard, ruffed grouse,

Table 13

RARE AND UNIQUE PLANTS OF THE PEMBINA RIVER SUBBASIN

Common Name	Status	Habitat	County
Meadow horsetail	Rare	Moist woodland	Pembina
Wood horsetail	Rare	Moist woodland	Pembina, Cavalier
Spikemoss	Rare	Open woodland	Pembina
Lady fern	Rare	Moist woods, meadows, and stream banks	Pembina, Cavalier
Spinulosa woodfern	Rare	Moist woods and along stream banks	Pembina
Shield fern	Rare	Along marshes and in wet woodland	Pembina
Sensitive fern	Rare	Moist open woodland	Pembina
Braken fern	Rare	Open woodland	Pembina
Floatingleaf pondweed	Unique	Submerged aquatic in ponds and lakes	Rolette
Sheathed pondweed	Unique	Submerged aquatic in ponds and lakes	Rolette
Carexsedge	Rare	Moist wooded areas	Cavalier
Water arum	Rare	Swampy areas and in shallow water	Pembina
Wolffia	Rare	Free-floating aquatic on ponds and lakes	Pembina
Showy ladyslipper	Rare	Boggy areas and wet wooded areas	Pembina
Loesel's twayblade	Rare	Wet wooded areas	Pembina
Bishop's cap	Rare	Boggy areas	Pembina
Water avens	Rare	Along margin of bogs	Pembina
Drooping pointloco	Rare	Upland prairie	Pembina, Cavalier
Bicknell sunrose	Rare	Upland prairie	Pembina
Bigleaf whiteviolet	Rare	Boggy areas	Pembina
Indian pipe	Rare	Rich woodlands	Rolette
Black ash	Unique	Woodlands on sandy soil	Pembina
Halenia	Rare	Rich woodlands	Pembina

and scarlet tanager. Additionally, the McLarty Grove area contains American elms up to 4.5 feet DBH (diameter at breast height) and 100 feet tall (Kantrud, 1973). See Figures III and IV for approximate locations of these areas.

V. FUTURE CONDITIONS

V. FUTURE CONDITIONS

The subbasin's future economic, social, and environmental conditions and resources are discussed below in terms of "most probable" and "without project" conditions.

Most Probable Economic Conditions

Communities and businesses in central and western Pembina County and, to a lesser extent, in Cavalier County underwent severe economic disruptions in the late 1970's following the deactivation of several defense installations in the area. Economic adjustment plans were formulated, and a sizable effort is being devoted to economic diversification, with emphasis on agriculture-related processing and indigenous industries. Because of these employment losses, the population and employment increases (seven percent) that were noted in Section IV as having taken place between 1970 and 1977 are not indicative of the future of this subbasin. The data presented in Table 14 below assumes a 1980 population level similar to the one estimated for 1977. A modest one percent per decade increase is forecast thereafter, based on similar experiences in areas with similar dislocations coupled with agricultural employment stabilization.

The figures in the table were adopted in lieu of the prescribed OBERS E projections, because those projections appear to underestimate growth patterns for the Grand Forks area, both metropolitan and environs. Steady declines through the year 2020 are anticipated by this series. OBERS E and E' projections were, however, designated as the most probable for per capita income and agricultural activity estimates.

Farming will continue to be the economic mainstay of the subbasin, with communities such as Pembina, Walhalla, Cavalier, and Langdon as employment, service, and retail centers for the large agricultural base. Grafton will continue to serve as the primary retail and wholesale center. Local leaders and area planners point to the need for diversification and the threat of possible inundation of some 90,000 flood-prone acres and the towns of Pembina, Neche, and Walhalla as the biggest obstacles to economic growth.

Table 14

PEMBINA RIVER SUBBASIN, POPULATION, EMPLOYMENT, AND PER CAPITA INCOME PROJECTIONS, 1980-2030

Parameter	1970	1977	1980	1990	2000	2010	2020	2030
Population	14,547	15,564	15,500	15,700	15,800	16,000	16,200	16,500
Employment	5,091	6,692	6,500	6,600	6,700	6,900	7,100	7,300
Per Capita Income (Dollars)	5,140	5,490	8,000	10,400	13,500	17,600	22,800	29,700

Sources: U. S. Water Resources Council, 1972 OBERS Projections, Series E; North Central Planning Council; and Gulf South Research Institute.

Most Probable Agricultural Conditions

Approximately one million acres within the subbasin are currently under cultivation, and wheat and barley are the principal crops. The total production of these two principal crops is estimated to be worth $57.8 million in 1980 (using October 1979 Current Normalized Prices for North Dakota). Projected production of the principal crops is presented in Table 15.

Table 15

PEMBINA RIVER SUBBASIN, PRINCIPAL CROPS AND PROJECTED PRODUCTION, 1980-2030
(Production in Thousands)

Year	Wheat (Bushels)	Barley (Bushels)
1980	12,990	10,551
1990	15,068	12,239
2000	17,147	13,928
2010	18,446	14,983
2020	19,745	16,038
2030	21,823	17,726

Sources: OBERS Series E'; and Gulf South Research Institute.

Evaluation of Flood Damages--Future Conditions

A summary of present and future average annual flood damages is presented in Table 16. Assuming a discount rate of 7 1/8 percent, equivalent average annual damages are $3.3 million.

Flood damages to residences, businesses, industrial structures, churches, schools, automobiles, house trailers, public property and contents are included in the urban damages category. Damages to streets and utilities (including water, gas, electricity, sanitary sewers, storm sewers, and telephone systems) are also taken into consideration. This category also includes loss of wages, loss of profits, expenditures for temporary

Table 16

PEMBINA RIVER SUBBASIN, SUMMARY OF PRESENT AND FUTURE AVERAGE ANNUAL DAMAGES
URBAN, AGRICULTURAL, AND TRANSPORTATION
(October, 1979 Prices, 7 1/8 Percent Interest)

Category	Flood Damages						Increase 1980-2030	Average Annual Equivalent Factor	Average Annual Equivalent of Increase	Equivalent Average Annual Damages
	1980	1990	2000	2010	2020	2030				
Urban										
Pembina	150,000	165,000	180,000	195,000	210,000	225,000	75,000	0.2903	21,800	171,800
Neche	30,000	33,000	36,000	39,000	42,000	45,000	15,000	0.2903	4,400	34,400
Walhalla	25,000	27,500	30,000	32,500	35,000	37,500	12,500	0.2903	3,600	28,600
Agricultural										
Crop	1,801,400	2,089,600	2,377,800	2,558,000	2,738,100	3,026,400	1,225,000	0.2903	355,600	2,157,000
Other Agricultural	600,500	648,500	696,600	726,600	756,600	804,700	204,200	0.2903	59,300	659,800
Transportation	227,000	227,000	227,000	227,000	227,000	227,000	----	----	----	227,000
TOTAL	2,983,900	3,190,600	3,547,400	3,778,100	4,008,700	4,365,600	1,531,700	0.2903	444,700	3,278,600

Source: Gulf South Research Institute.

housing, cleanup costs, and extra expenses for additional fire and police protection and flood relief.

Agricultural flood damages consist of crop and pasture damage, which may include costs of replanting, refertilizing, additional spraying, reduced crop yields, loss of animal pasture days, and other related flood losses.

Other agricultural damages consist of land damage from scour and gully erosion and deposition of flood debris; livestock and poultry losses; damages to machinery and equipment, fences, farm building and contents (excluding residences); and damages to irrigation and drainage facilities.

Transportation damages include all damages to railroads, highways, roads, airports, bridges, culverts, and waterways not included in urban damages. In addition, all added operational costs for railroads and airlines and vehicle detours are included.

Future growth of urban flood damages was estimated to be an uncompounded (straight-line) rate of one percent per year for a 50-year period beginning in the base year, with no growth thereafter.

Agricultural crop flood damages were projected to increase at the same rate as crop income projections published in the 1972 OBERS Series E projection report. These crop income projections were prepared by the U.S. Economic Research Service (ERS) for the Red River of the North region. Other agricultural flood damages were projected to increase at one-half of this rate.

Transportation damages are not expected to change throughout the project life because of the long-term economic life associated with such structures as bridges, railways, roads, and culverts. In addition, it has been found that repairs to these types of structures rarely exceed the cost of a new structure, even with frequent flooding.

Most Probable Environmental Conditions

Improvements in water quality will occur with successful implementation of point and nonpoint source pollution abatement programs. The nonpoint source program, which should alleviate problems with high sediment loads, will take substantially longer to implement.

Woodland acreages will deteriorate unless the state is sucessful in obtaining ownership of the extensive native forests in the subbasin. This problem was discussed in the Problems and Needs section of this report. Although the state has placed a moratorium on wetland drainage by government agencies in the upper part of the subbasin (U.S. portion), drainage on private lands continues. The U.S. Army Corps of Engineers (1977a) indicated that the drainage rate should decrease because of the following reasons:

1. The majority of small shallow wetland areas in the upper basin have already been drained and converted to agricultural uses.
2. Pressure by various interest groups will probably cause existing water management boards responsible for providing permission for all drainage projects, including private drainage, to exercise their responsibility more conscientiously on the remaining wetland areas.
3. A cooperative approach to drainage problems similar to that being applied to the adjacent Devils Lake Subbasin has been suggested by several interests.
4. For the most part, drainage of U.S. lands in the upper Pembina River Subbasin crosses the International Border into Canada. The general rule governing these drains and creeks is that they may be maintained but not enlarged.
5. The above points indicate the increasing importance of land use planning, which should have a significant influence on future changes in existing land use.

Even though the drainage rate may decrease, the important point is that it will probably continue with the resultant effect of reducing the number and areal extent of this important resource.

Commensurate with the expected reduction of woodlands and wetlands, is the decrease in plant and animal populations associated wholly or in part with these habitat types.

Without Project Conditions

In the absence of a plan to alter resource management procedures, it is anticipated that the conditions that will prevail between 1980 and 2030 will be the same as those described as being the most probable.

VI. EXISTING FLOODPLAIN MANAGEMENT PROGRAMS

VI. EXISTING FLOODPLAIN MANAGEMENT PROGRAMS

Institutions

The development of effective water resources management practices in the subbasin is affected by the larger number of Federal, state, and local agencies involved in project planning and implementation. There are 44 Federal agencies with various types of jurisdiction, and 14 directly involved in the water and related land resource planning process. At the state level, seven agencies are involved. There are also international agencies (since the subbasin extends into Canada), regional commissions, county agencies, and municipal entities. Differences in perspective and problems of coordination hamper the effective and speedy resolution of problems.

The primary local agencies involved in water resources management in the subbasin are the water management districts for Pembina, Cavalier, Towner, and Rolette counties. The districts have broad powers to develop and implement programs related to flood control, water supply, water conservation, and other problems related to water resources management. The water management districts in the Pembina Subbasin have not developed overall plans, and there is no overall plan that encompasses the entire subbasin area.

The major Federal agencies with water resource development interests in the area are the Soil Conservation Service (SCS) and the St. Paul District Corps of Engineers. There are four soil conservation districts with authority in the subbasin, including Rolette, Towner, Cavalier, and Pembina districts.

The Corps of Engineers completed one project at Pembina in 1977, and the Pembilier Lake multi-purpose project is authorized for Phase I GDM studies. The Soil Conservation Service completed a watershed protection project for the Tongue River. The Corps of Engineers, SCS, the various water management and soil conservation districts, and the towns of Pembina, Neche, and Walhalla should be taken into consideration in flood control planning for the subbasin. The Red River and North Central planning councils have developed comprehensive land use plans that include the subbasin area.

Structural Measures

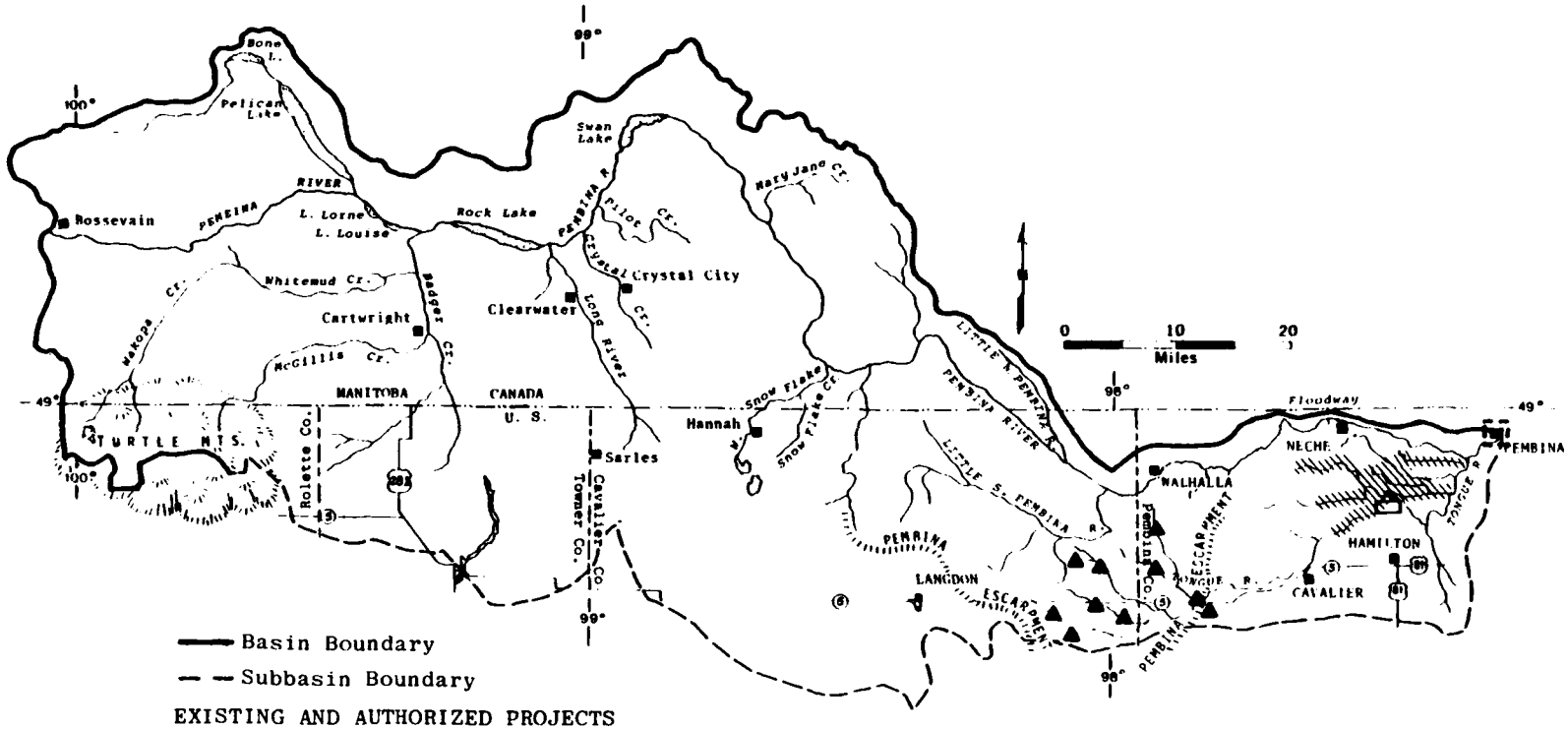
There are very few existing water resource projects within the subbasin. There have been a considerable number of public and private ditches and drains constructed that function satisfactorily for relieving minor localized flooding within the areas which they drain. These drainage systems, however, are inadequate for major floods and are not extensive enough to substantially relieve minor flooding problems.

Floodwater control and agricultural water management (drainage) measures have been constructed by the Corps of Engineers, Soil Conservation Service (SCS), and private interests. These structural projects are shown on Figure V and include the following:

1. The SCS under the pilot watershed program that proceeded Public Law 566 completed, in the early 1960's, interrelated water and land treatment and structural improvement measures for a 462-square mile area of the Tongue River Watershed in Cavalier and Pembina counties, North Dakota. Watershed protection works and measures include 10 floodwater retarding structures, 20 miles of stream channel improvement, 11 miles of floodways, and clearing and snagging of an additional 20 miles of stream channel. The 10 reservoirs are located on the upper tributaries and upper reaches of the main stem of the Tongue River. Their storage capacities range from 180 to 4,800 acre-feet, with a total storage capacity of 18,000 acre-feet. This project was the pioneering effort for the watershed approach to conservation and flood protection.

2. Under the provisions of Section 205 of the 1948 Flood Control Act, as amended, a local flood protection project was constructed by the Corps of Engineers at Pembina, North Dakota. It was completed in 1977 and included a combination levee and floodwall encircling the town, interior drainage facilities including a pumping station and ponding area, interceptor sewers and ditches, and related highway and railroad improvements. Since the town of Pembina is located at the confluence of the Pembina River and the Red River of the North, this project protects the town from flooding caused by both streams. However, Red River flooding is far more serious than Pembina River floods, and the improvements were designed and constructed to provide protection against a Red River flood having a peak discharge of 151,000 cfs, which is a 0.67 percent (160-year) flood.

3. Agricultural levees constructed by private interests in both the United States and Canada.



Source: Gulf South Research Institute.

Figure V. EXISTING FLOOD CONTROL MEASURES

In addition to these projects, the Corps of Engineers completed a study on snagging and clearing of the Pembina River from its junction with the Red River to a point west of Neche, North Dakota. This study considered removing standing trees between the shoreline and top of primary banks, removing leaning trees on primary banks, and debris removal along the lower 33 miles of the Pembina River. The study was terminated in 1978 because the costs to local supporters increased until they surpassed the Federal authorized limit.

A SCS watershed project was under consideration for the Bathgate-Hamilton area, which comprises 167 square miles. Detailed planning was authorized under PL-566. This entire watershed is in the Red River floodplain. There are no feasible retardation sites in the watershed. A plan of channel work was studied and presented to land owners. Lack of local support for this plan caused it to be suspended.

Nonstructural Measures

Nonstructural flood control measures are measures that reduce or eliminate flood damages through procedures that involve little if any construction efforts. The major types are flood warning, floodplain zoning, flood insurance, flood proofing, and floodplain evacuation. These measures are primarily applicable to urban areas.

The towns in the subbasin participate in the Red River Valley flood warning system. The flood warning system for the Red River Valley is a cooperative network organized by the National Weather Service in Fargo, North Dakota. Fifty volunteers throughout the basin report to the National Weather Service on a weekly basis during winter and fall and on a daily basis during spring and summer. The reportage covers all precipitation of 0.1 inch or more, including amounts of snow and water equivalent. This information is transmitted to the River Forecast Center in Minneapolis, where it is run through a computer system to determine probable flood stages. The predictions are then transmitted to the National Weather Service in Fargo, which releases them to the public through the news media. Communities are then able to engage in emergency actions to protect themselves from flood damages. Contacts with local officials indicate that the flood warning system generally works quite well in the subbasin.

The city of Neche and the townships in Pembina and Cavalier counties either have adopted or will adopt resolutions controlling land use. Persons living in flood prone rural areas will soon be eligible to participate in the Federal flood insurance program, but presently there seems to be some confusion over which governmental bodies in North Dakota will be responsible for rural floodplain regulations.

There are other types of measures that could be implemented in the subbasin to reduce flood damages but that are not directly applicable to urban areas. These measures would include such things as land treatment programs, use of present drainage ditches for floodwater storage, and use of natural areas for water retention. Land treatment is used by some farmers in the subbasin, but the Soil Conservation Service has not been called upon to undertake a large-scale program. Present drainage ditches are not used for floodwater storage, and no plans have been developed for future use. Information on natural storage areas and potentialities for increased storage is not available.

Adequacy of Existing Measures

Public and private ditches are not adequate for large floods, nor are they extensive enough for minor flooding problems. The SCS Tongue River Watershed project has been very successful and has practically eliminated crop losses due to flooding in this 462-square mile watershed. Flood damages at Pembina during the flood of 1978 and the near record flood of 1979 caused minimal damage as a result of the new flood protection system.

Flooding problems in this subbasin are most acute in the broad, low floodplain from the escarpment west of Walhalla, North Dakota to the Red River. Flood flows in the floodplain inundate a large rural area. Frequently, flood waters from the Pembina River Flow south overland into the Tongue River area or north into the aux Marais River area in Canada. This situation has resulted in the construction of agricultural levees on both sides of the river in North Dakota and a 15-mile roadway levee in Canada. These levees have changed natural flow conditions of the river and have caused considerable controversy between Canadian and American interests. The only urban areas affected by floods are the communities of Neche and Walhalla, North Dakota.

Presently, there are no floodwater control nor agricultural management (drainage) projects under construction in the subbasin. Although implemented structural measures are functioning satisfactorily, their overall effect on flooding in the subbasin is negligible. Recurring flooding is still a serious problem throughout the subbasin, and additional flood control measures are needed to reduce flood damages.

VII. CRITERIA AND PLANNING OBJECTIVES

VII. CRITERIA AND PLANNING OBJECTIVES

Floodplain Management Criteria

Technical, economic, and environmental criteria must be considered when formulating and evaluating alternative floodplain management measures for the subbasin.

The technical criteria used in formulating and evaluating alternatives for this report consisted of the application of appropriate engineering standards, regulations, and guidelines.

Economic criteria entailed the identification and comparison of benefits and costs of each measure. Tangible economic benefits must exceed costs; however, in certain instances, considerations of appropriate gains in the other accounts (environmental quality, social well-being and regional development) could alter this requirement. All alternatives considered are scaled to a design which optimizes benefits. Annual costs and benefits are based on an interest rate of 7 1/8 percent and price levels and conditions existing in October 1979. A 50-year amortization schedule is used for the features considered.

Environmental considerations call for the formulation of measures that minimize objectionable or adverse environmental effects and maximize environmental benefits. Also, limited consideration was given to modifications based on coordination with state and Federal agencies, local interests, and citizen groups.

Planning Objectives

The primary planning objective of this study was to contribute to flood reduction needs in the subbasin and thereby provide protection from or reduction of flood losses. In conjunction with this economic objective, the study attempted to develop contributions to the environmental quality of the subbasin.

The development of planning objectives involved a broad-range analysis of the needs, opportunities, concerns, and constraints of the subbasin from the information available. On the basis of the identified problems, needs, and desires, the following planning objectives were established:

1. Contribute to protection from and prevention, reduction, or compensation of flood losses for the flood prone areas of the subbasin during the period of analysis.

2. Contribute, to the maximum extent possible, to the preservation of the quality of the existing riverine environment and to the reduction of woodland clearing in order to preserve wildlife habitat.

3. Contribute to the enhancement of recreational opportunities throughout the subbasin, particularly in the western portion and in the area east of the escarpment.

4. Contribute to the improvement of water quality in the Pembina River, specifically with respect to low dissolved oxygen, high nitrates, and phosphates.

5. Contribute to the improvement of water supply in the area east of the escarpment.

6. Contribute to the reduction of bank and sheet erosion and sediment deposition throughout the subbasin.

7. Contribute to the investigation of groundwater resources so that irrigation can be utilized, where necessary, in the subbasin.

8. Contribute to the reduction of wastewater management problems, particularly insofar as they relate to water quality.

VIII. FORMULATION OF ALTERNATIVE MEASURES

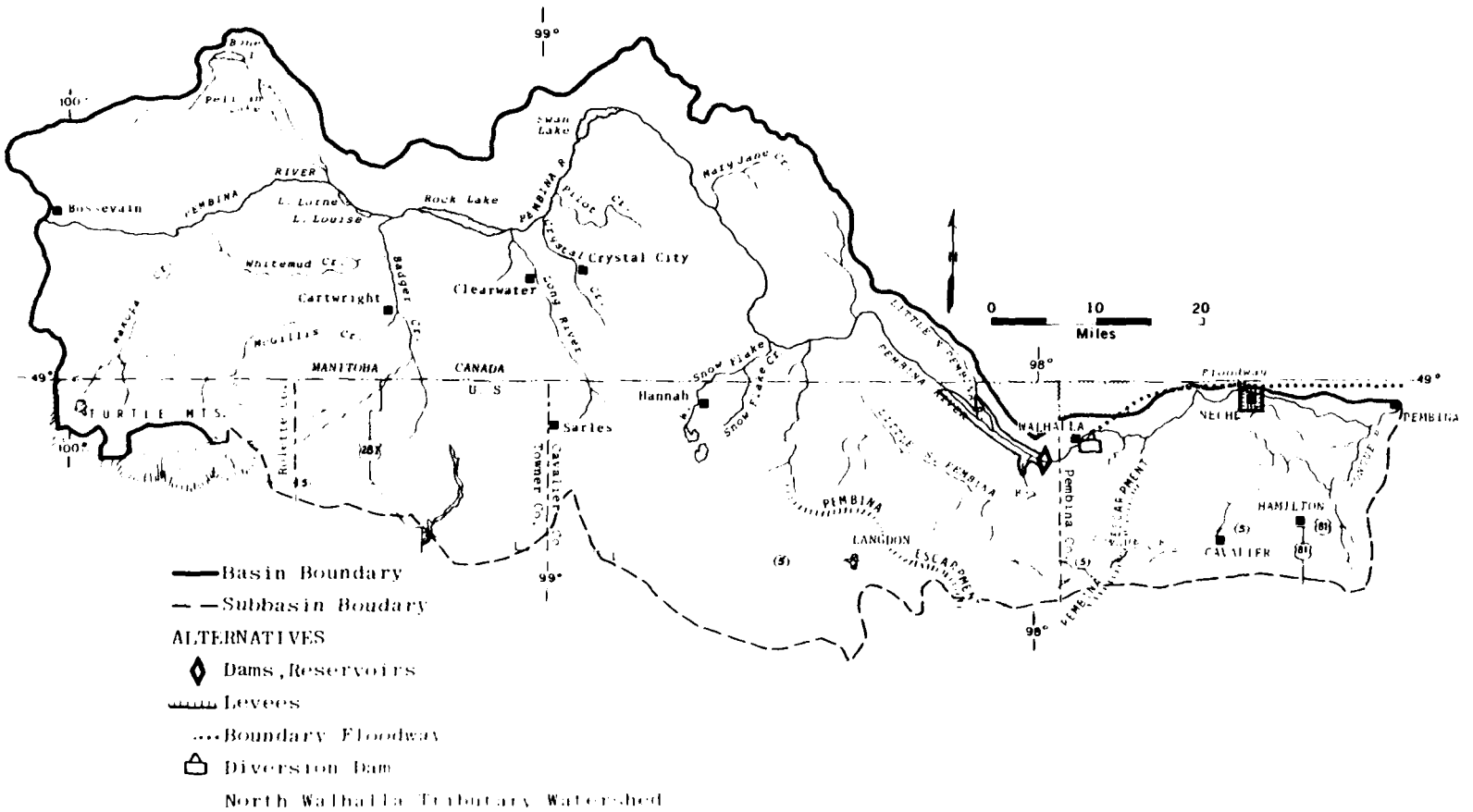
VIII. FORMULATION OF ALTERNATIVE MEASURES

Management measures that have been identified to satisfy the resource management objectives are discussed in this section. In the formulation of measures, prime consideration was given to the resolution of flooding problems. Measures to satisfy the other planning objectives were considered exclusively as components of the flood control measures.

The following measures, which are illustrated in Figure VI, were devised in response to the flood control planning objective:

1. Construction of the multi-purpose Pembilier Dam and Lake near Walhalla, North Dakota. This Corps of Engineers project has been authorized for Phase I GDM studies. When completed, the reservoir would protect Walhalla and all of the subbasin east of Walhalla, except the town of Neche, against the 2.8 percent (36-year) flood and would provide 11 percent (nine-year) flood protection for Neche. This project will permit containment of the 2.8 percent flood within the reservoir and the present Pembina River channel and would substantially reduce flood damages throughout the subbasin in both the United States and Canada. It would resolve the present controversy between Canadian and American interests by eliminating the need for the present agricultural levees and the 15-mile roadway levee in Canada. The project would provide for significant control of the runoff from about 85 percent of the subbasin and would reduce average annual agricultural damages in the United States by 80 percent and in Canada by 20 percent. The multi-purpose reservoir is the only plan that is in agreement with the reports of the International Joint Commission and the Souris-Red-Rainy River Basins Commission. This plan is strongly supported by state and local interests; however, the U.S. Fish and Wildlife Service has certain reservations about it.

   Although the Pemblier project would substantially reduce flood damages from Pembina River floods, it would have very little effect on Red River main stem flood damages. Along the United States portion of the Red River downstream of its junction with the Pembina River, this project would reduce average annual damages by only about 1.5 percent, thereby providing little benefit along the main stem. A similar small reduction would occur along the Canadian portion of the main stem downstream of the international border. It should also be noted that the Pembilier project would have no effect on flooding in the lower portion of the subbasin caused by backwater from main stem floods. However, when main stem and Pembina River floods occur simultaneously, the project would significantly reduce flooding in the subbasin.



Source: Gulf South Research Institute.

Figure VI. ALTERNATIVE FLOOD CONTROL MEASURES

2. The Pembilier Dry Dam project (at the site west of Walhalla, in place of a multi-purpose reservoir) would provide the same amount of flood storage (128,000 acre-feet) but provides no public water supply or recreational benefits. This project, while economically feasible, does not supply the aesthetic objectives, and local and state interests prefer the multi-purpose reservoir. Flood damage reduction and average annual benefits for this measure would be about the same as those for the multi-purpose reservoir. The Corps of Engineers would be the implementing agency.

3. Construction of a ring levee and related facilities at Neche, North Dakota. This measure would provide one percent (100-year) flood protection for Neche and would be implemented by the Corps of Engineers.

4. Construction of a boundary floodway along the Canadian border from near Walhalla to the Red River just downstream of Pembina. This alternative consists of a small diversion dam about three miles downstream from Walhalla that would permit normal flows to remain in the natural channel but would divert flood flows into a floodway. This floodway would extend 32.6 miles from the diversion dam generally north of the international boundary and then directly east just south of the boundary to the Red River. This measure provides nine percent (11-year) flood protection for rural areas and 14 percent (seven-year) flood protection for Neche. It could also contribute to peak flows of the Red River. The Corps of Engineers would implement this measure.

5. Preliminary studies relative to a watershed project in the North Walhalla Tributary of Pembina River indicated that a project in this 50 square mile watershed would be feasible. Structural measures included floodwater retarding structures in combination with channel modifications. The problem with this measure is one of inadequate outlets in Canada for the design flows of channel work proposed in the United States, which resulted in planning being terminated. Because of the international nature of the flooding problem, a committee made up of U.S. and Canadian officials was appointed to study the problem. This committee ultimately produced a report recommending improvement that would provide adequate channels in Canada. A draft agreement based on the findings of this report has been prepared and is now being reviewed by both governments. The SCS would implement this project.

Engineering Methodology

The four Corps of Engineers alternative measures were developed from prior studies and reports relative to flood control measures in the subbasin.

Capital costs and benefits obtained from these studies and reports were updated to October, 1979 price levels using accepted cost and price indexes. Capital costs and benefits for the SCS project were derived from composite costs and benefits per acre of watershed improvement developed from completed watershed improvement projects in the Red River Basin. Capital costs and benefits reflect October 1979 levels.

Nonstructural Measures

Among the nonstructural measures considered in previous Corps reports were flood warning and forecasting services, emergency protection, permanent floodplain evacuation, and flood proofing. The conclusions of these reports with respect to the various nonstructural measures are discussed in the following paragraphs.

Floodplain regulation and flood insurance are currently required by Federal policies and are encouraged by the State of North Dakota and thus were identified as the base condition in various reports. Local governmental units were required to participate in the flood insurance program by 1 July 1975 or no later than one year after the date of issuance of the floodplain hazard boundary map, whichever is later. Once flood insurance rate studies are completed, permanent land use controls must be adopted by local communities within six months. Over a long period of time, all nonconforming floodplain structures would be eliminated, thereby reducing flood damages. However, because home and business owners in flood prone areas can obtain structural improvement loans through the purchase of flood insurance, and because the value of the contents of these structures can be expected to increase, flood damages will increase in the near future even with floodplain regulations in effect.

Unsubsidized crop insurance is available through the U.S. Department of Agriculture Federal Crop Insurance Program, which covers all natural disasters including floods. However, actual crop damages could be reduced only to the extent that intensive farming practices would be discouraged over a long period of time in the floodplain. Because of the highly productive nature of floodplain farming, it is very doubtful that any long-term shifts away from the intensive farming of floodplain areas would occur. Thus, the base condition is not seen as an effective measure for reducing flood losses in the subbasin.

Flood warning and forecasting services in conjunction with emergency protecion have been used with reasonable success. However, the amount of time between the flood warning and forecasting and the actual flood event is critical to the type of emergency works that can be implemented. Also, the larger the magnitude of the flood, the greater the structural stability problems caused by underlying soil conditions. In addition, the greater danger of failure would increase the potential for loss of life. Emergency protection measures would continue to inconvenience and disrupt residents of the floodplain and would disrupt the biological system and scenic quality of the area. Therefore, this alternative is not perceived as socially, environmentally, or economically acceptable as a solution to the total flood problem. However, it is recommended that flood warning and forecasting services be continued in order to alert floodplain residents of impending dangers.

Permanent evacuation of flood prone areas would consist of the acquisition of lands, relocation of improvements, and resettlement of the population, ultimately resulting in the conversion of land use to a state less susceptible to flood damages. Impacts of the implementation of this alternative would primarily be cultural and economic in nature. Flood proofing would involve structural changes and adjustments to properties in an effort to reduce or eliminate flood damages. This is most effective when applied to existing structures in some instances. Permanent evacuation would result in the disruption of long-established social and cultural relationships, but could eliminate flood damages to structural units, providing floodplain regulations were enforced. Furthermore, the health and safety of floodplain residents would be benefited and natural habitats would be improved. However, the residual damages to agriculture, and the economic, social, and cultural impacts would more than offset the benefits.

The preceeding discussion summarized the results of Corps of Engineers investigations. In addition to the nonstructural measures mentioned in the Corps reports, there is an opportunity for the use of land treatment measures throughout the subbasin that would help to contain water on land as well as reduce erosion damages. Other measures would include

but not be limited to water retention in existing ditches and preservation of natural retention areas. These would need to be identified, and retention capacities would need to be determined. Wetland restoration could also be considered, where appropriate, for water retention.

IX. ASSESSMENT OF ALTERNATIVES

IX. ASSESSMENT OF ALTERNATIVES

Economic Assessment

An economic evaluation of proposed flood control alternatives is presented in Table 17. The four Corps of Engineers alternative measures (alternatives 1 through 4) were developed from prior studies and reports relative to flood control measures in the subbasin. Capital costs and benefits obtained from these studies and reports were updated to October 1979 price levels using accepted cost and price indexes. Capital costs and benefits for the Soil Conservation Service (SCS) project were derived from composite costs and benefits per acre of watershed improvement developed from completed watershed improvement projects in the Red River Basin. Capital costs and benefits reflect October 1979 levels.

Alternative 1 consists of a large multi-purpose reservoir (147,000 acre-feet) for flood control, water supply, and recreation. The multi-purpose dam would regulate much of the runoff from the subbasin, thereby reducing flood damages at Neche and partially alleviating flooding downstream. Economic evaluation of this alternative yielded a benefit/cost ratio of 1.32.

Alternative 2 consists of a large dry dam (141,000 acre-feet) at the same location proposed for Alternative 1. There would be no permanent lake. Water would be stored only during a flood or as necessary to minimize downstream flooding. Economic evaluation of this alternative yielded a benefit/cost ratio of 1.20.

Alternative 4 consists of a small diversion dam that would permit normal flows in the natural river channel but would divert flood flows into a floodway. Economic evaluation of this alternative yielded a benefit/cost ratio of 1.05.

Alternative 5 is a watershed project in the area of the North Walhalla Tributary of the Pembina River. This alternative consists of structural measures which include floodwater retarding structures in combination with channel modifications. Economic evaluation of this alternative yielded a benefit/cost ratio of 0.99.

Table 17

ECONOMIC EVALUATION OF ALTERNATIVES, PEMBINA RIVER SUBBASIN

Alternative	Acres Protected	Average Annual Acres	Capital Costs	Average Annual Costs	Average Annual Rural Benefits	Average Annual Urban Benefits	Total Average Annual Benefits	B/C Ratio
1. Multipurpose Pembilier Dam and Lake (2.8% flood)	--	--	$35,178,000	$2,589,500	$3,324,700	$102,800	$3,427,500	1.32
2. Pembilier Dry Dam (2.8% flood)	--	--	34,872,000	2,566,900	2,987,000	95,300	3,082,000	1.20
3. Urban Levees at Neche (1% flood)	--	--	1,983,000	146,000	--	91,100	91,100	0.62
4. Boundary Floodway (9% flood)	--	--	31,453,000	2,315,300	2,353,800	72,798	2,426,600	1.05
5. Channel Improvements/ Pembina River Watershed	--	--	794,000	58,400	58,000	--	58,000	0.99
6. Farmstead Levees (Per Levee)	--	--	5,600	400	840	--	840	2.10

Source: Gulf South Research Institute.

Alternative 6 consists of the construction of farmstead levees around individual farmsteads located in the one percent frequency floodplain. Economic analysis of this alternative yielded a benefit/cost ratio of 2.10. Evaluation of this alternative involved the assumption of implementation by private interests.

Urban benefits for alternatives 1 through 4 were assumed to be three percent of total benefits. This assumption was based on information presented in the Pembina River, North Dakota, Feasibility Report for Flood Control and Related Purposes completed by the Corps of Engineers in March 1976.

Impact Assessment

Table 18 presents a generalized assessment of the effects on the resource elements that can be expected if structural measures were to be implemented. The impacts of the proposed Pembilier Lake and Dam project were obtained from the December 1979 Final Environmental Impact Statement, Pembilier Lake and Dam, Pembina River Basin, North Dakota. The feasibility report issued in March 1976 for the Pembina River, North Dakota was also utilized. Both documents were prepared by the St. Paul District.

Pembilier Lake and Dam

The proposed reservoir would have maximally beneficial economic effects because of the reduction of urban and rural flood damages in the subbasin. Flood protection would be afforded to some 14,000 acres annually, with average annual flood control, water supply, and recreation benefits of approximately $3.4 million. Flood storage estimates indicate that there would be a 72 percent reduction in projected average annual equivalent damages.

Two farmsteads and residences are within the project take-line. Persons living in protected areas would experience less rural community disruption and fewer threats to public health and safety during flood periods. Those individuals owning a total of about 800 acres (350 acres of agricultural lands) would have to sell property necessary for the project. Overall, social benefits were deemed to be maximally beneficial.

Table 18

ASSESSMENT OF MEASURES, BY RESOURCE ELEMENT,
PEMBINA RIVER SUBBASIN

Measures	Social	Economics	Land Use	Biology	Water Quality	Water Supply	Cultural	Recreation
1. Multipurpose Pembilier Lake and Dam (2.8 Percent Flood)	MaB	MaB	MiA	MaA	MoA	MaB	MoA	MoB
2. Pembilier Dry Dam (2.8 Percent Flood)	MoB	MoB	MiA	MoA	MiA	NKE	Mia	NKE
3. Urban Levees--Neche (1 Percent Flood)	MoB	MoB	NKE	MiA	NKE	NKE	NKE	NKE
4. Boundary Floodway (9 Percent Flood)	MiB	MiB	MiA	MiA	MiA	NKE	NKE	NKE
5. Channel Improvements/ Pembina River Watershed	MiB	MoB	NKE	MaA	MiA/MiB	NKE	NKE	NKE
6. Farmstead Levees	MiB	MiB	NKE	NKE	NKE	NKE	NKE	NKE

Note: NKE = No Known Effect
MiA = Minimally Adverse
MoA = Moderately Adverse
MaA = Maximally Adverse
MiB = Minimally Beneficial
MoB = Moderately Beneficial
MaB = Maximally Beneficial

Source: Gulf South Research Institute.

Making farming in the floodplain more profitable could well influence land use and agriculture. Total project land would encompass about 800 acres, of which 370 acres have native vegetation and 350 are agricultural. This along with more intensive use of existing lands and possible clearings for additional farming might well occur. The net effects from a land use standpoint would be minimally adverse.

Maximally adverse biological impacts would result from the proposed measure. The project would modify or destroy existing ecosystems of floodplain forests, agricultural lands, and streambeds. Reduction and changes in habitat and disruption of ecological balances would affect vegetation and wildlife well beyond the limits of the design flood pool. Several endangered species could be affected, and there is a likelihood of eutrophication after impoundment.

Water quality would also be affected negatively. Turbidity and sedimentation would be affected by construction. The extent of the effect would depend on such factors as streamflow and rainfall at the time of construction. Although suspension of sediments in the water is temporary, the resultant siltation on downstream areas is permanent. The lake, however, would also trap sediments that would otherwise go to downstream reaches.

A recreation plan developed in conjunction with this measure would provide water-based recreational opportunities through utilization of the conservation pool and surrounding project lands.

Water supply would be maximally beneficially affected by the Pembilier measures. Cultural resources would be moderately adversely affected, since 19 lithic archaeological sites are present and would be destroyed by the project.

The Pembilier Dam would have backwater and downstream effects in Canada. Backwater effects appear to be minimally detrimental (40 acres of land in Manitoba would be flooded, while annual inundation reduction benefits of over $300,000 would accrue in the Gretna-Altona and Emerson areas of the same province.

Pembilier Dry Dam

Moderately beneficial social and economic benefits would result from a dry dam measure. The degree of protection provided by such an alternative would be the same as for the proposed reservoir, but the area would not accrue the benefits associated with water supply and recreation. Moderately adverse biological and water qualify effects would likely be experienced, largely due to effects on a natural area, the permanent loss of riparian community associated with clearing, and possible detrimental effects on threatened and endangered species. The dry dams' lower trap efficiency would allow for the passage of more sediments downstream, with possible negative effects upon the aquatic biota in those reaches. In comparsion to the lake and dam, there would be fewer but similar adverse effects on land use and cultural resources. Negligible effects would take place on water supply and recreational elements.

Urban Levees--Neche

Prevention of flood damages at Neche would result in moderately beneficial social and economic effects to the community and subbasin. These beneficial effects include the reduction or prevention of damages to and/or loss of personal property, the potential for disruptions in the delivery of emergency services, drains on community services, temporary or permanent loss of community facilities, loss of community tax base and losses in personal income. In addition, such measures would serve to reduce many of the negative behavioral consequences associated with flooding problems. No known effects would probably be experienced by land use, water quality and supply, cultural elements, and recreational elements.

Minimally adverse environmental and biological impacts would accrue as a result of project construction. Some streamside floodplain vegetation would be destroyed by project construction, and there would be minor degradation in aesthetic qualities and temporary air and noise pollution.

Boundary Floodway

Minimally beneficial social and economic benefits would result from such measures, since the inundation reductions and intensified agricultural practices are somewhat offset by the 1,000 acres needed for the floodway

channel and the 1,400 acres required for dredged material disposal. Almost all of the land affected would be agricultural. Minimally adverse biological and water quality effects could be anticipated. Some existing habitat would be lost, along with the possible induced clearings of wooded lands. At the same time, a grassland-type habitat would be created along the channel. Water quality would be degraded in the Red River of the North due to increased turbidity, reduced assimilative capacity, and increased temperature. Similar minimally adverse land use changes would take place. While it is not known to what extent, cultural elements, recreational aspects, and water supply would be affected.

Channel Improvements

Channel improvements would yield minimally beneficial social and moderately high economic effects, severe adverse biological effects, and short-term adverse but long-term beneficial results for water quality elements. It is not known what effects would take place with respect to land use, recreation, water supply, and cultural elements.

Social and economic benefits would accrue from the flood protection and flooding reductions that would stem from the project. Biological and water quality elements would be affected negatively by dredging activities, vegetation removal, and temporary turbidity. Water quality should, however, improve in the long run as stream flows are enhanced.

Farmstead Levees

Minimally beneficial economic and social effects would result from the protection of several farmsteads in the 100-year floodplain. All other resource elements would not be significantly affected, although consideration must be given to public health and aesthetic factors prior to their construction.

X. EVALUATION

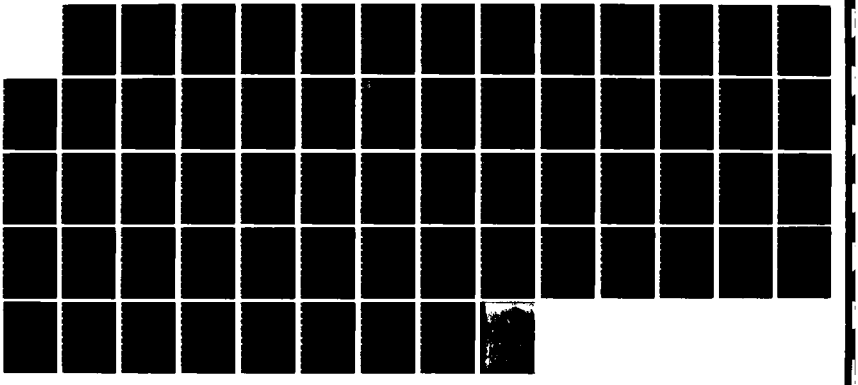
X. EVALUATION

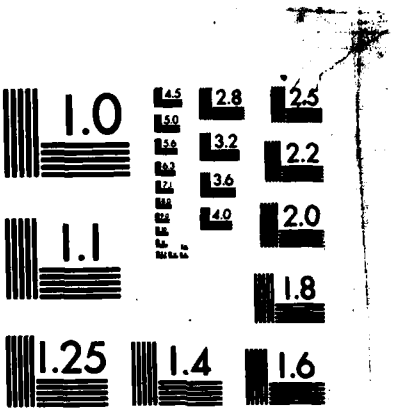
Five alternative measures considered for the subbasin have benefit/cost ratios that exceed unity. They are the Pembilier multi-purpose reservoir, the Pembilier Dry Dam, the Boundary Floodway, the farmstead levees, and combinations of these structural and some non-structural measures. The channel improvements are slightly below unity.

Pembilier Lake would meet the flood protection needs of the subbasin and would best meet National Economic Development (NED) objectives according to the Environmental Impact Statement prepared in 1977. Total project benefits are greater than costs, and substantial flood damage reductions would result. The social well-being (SWB) account would be enhanced by public health and safety improvements, flood damage reductions, and provision of additional water-based recreational opportunities. The Environmental Quality (EQ) account would receive basic changes, several of which are negative. In association with the EIS, an EQ plan was considered that would include components of various measures such as boundary floodway, off-channel water supply storage at Neche, floodplain regulation and flood insurance at flood prone communities and rural areas, flood warning and forecasting, modifications to existing levees at Neche, and land management practices. The benefit/cost ratio of the EQ alternative is 1.15.

AD-A140 787 RED RIVER OF THE NORTH RECONNAISSANCE REPORT: PEMBINA RIVER(U) GULF SOUTH RESEARCH INST BATON ROUGE LA DEC 80 DACW77-80-C-0017 2/2

UNCLASSIFIED F/G 8/8 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

XI. ADDITIONAL STUDY NEEDS

XI. ADDITIONAL STUDY NEEDS

This report was developed almost entirely on the basis of secondary information from readily available planning documents. Data available from state and Federal agencies was not fully canvassed, and only a limited number of calls were made to the area. In particular, state university libraries and department resources could not be fully utilized. Thus, the document aims only at a broad-brush perspective. In order to provide a more detailed and in-depth analysis of subbasin resources, problems, and potential solutions, the following additional study needs would have to be fulfilled:

1. A literature search should be conducted to obtain available biological data for the subbasin. Fieldwork should be planned to fill in any data gaps which exist with the end result of obtaining good baseline data for the subbasin. This is particularly necessary in those areas where flood control measures have been proposed, other than at the authorized multi-purpose dam near Walhalla.
2. Areas of high environmental quality (e.g., prairie remnants and riparian woodlands) should be identified and inventoried within the subbasin.
3. Updated knowledge of the location, areal extent, and types of wetlands occurring within the specific subbasin boundaries would be extremely useful in determining whether wetland restoration would assist in alleviating flooding problems, as has been indicated by Cernohous (1979), and would provide a comparison for documenting wetland losses since the 1964 inventory.
4. Primary water and sediment quality data are needed to update baseline conditions in the streams of the subbasin, particularly in those areas where flood control measures have been proposed.
5. Information pertaining to wastewater management needs to be updated.
6. The information obtained in items 1-5 above would provide an important data base upon which an impact evaluation of proposed flood control measures can be performed and would provide information relative to the cumulative effects of flood control projects on environmental resources in the subbasin. These projects include those that are in place or proposed.
7. Nonstructural flood damage reduction measures should be thoroughly explored such as those listed below.

- Establishment of buffer areas and curtailment of inappropriate residential, commercial, and other development in floodplains.
- Maintenance and enhancement of existing riparian vegetation along the Pembina River and tributaries to conserve and restore wildlife habitats, help control wind and streambank erosion, retain soil on the land, and reduce the amount of sediment, nutrients, and other pollutants entering waterways.
- Maintenance of grassed waterways to reduce erosion.
- Establishment of vegetation in areas of critical erosion.
- Determination of the feasibility of installing water control structures at existing culverts to retain water in drainage ditches for longer periods of time during critical runoff periods to minimize flooding in downstream areas.
- Determination of the feasibility of utilizing "on-farm storage" to control runoff through such means as natural storage areas and control structures on existing culverts.
- Prevention of overgrazing on grasslands and utilization of sound agricultural land use practices.
- Provision for strict enforcement of floodplain managment programs within the subbasin.
- The potentiality for land treatment measures (e.g. erosion control measures such as cover crops, green belts, reduction in fall tillage, etc.) needs to be thoroughly investigated.

8. The people of the subbasin need to be included in further water resource planning efforts. A public involvement program would provide more complete information on water resource problems and opportunities than is presently available.
9. More study is needed to determine the precise nature of the water supply problems and potential solutions.
10. Potentialities for floodwater storage in present drainage ditches need to be investigated.
11. The effect of drainage works on flood discharges and stages is unknown at present. It would take additional, more detailed studies to determine the extent and effect of reduced natural storage.
12. Land use within the floodplain needs to be precisely identified.
13. An adequate 100-year floodplain map needs to be developed. Also, the extent of floodplains for smaller frequency storms needs to be delineated.

14. More gauging stations need to be developed to provide hydrologic data for establishing flood frequencies and rating curves.

15. Channel cross-sections of the various streams need to be prepared for flood control planning purposes.

16. Crop distribution in the floodplain needs to be precisely identified through contact with county agents, and average annual rural damages need to be updated.

17. The irrigation potentials of the subbasin soils need to be investigated.

18. A comprehensive and up-dated inventory of recreation sites would be required to accurately identify resources.

19. Studies are needed to determine additional demand for recreational facilities, usage of existing facilities, and potential sites.

20. A regional supply and demand analysis for hunting, fishing, and other water based or related recreational pursuits is needed.

21. Whether forested acreages in the floodplain are increasing or declining needs to be precisely determined.

22. A detailed study of the objectives, goals, and programs of the many institutional entities involved in water resources planning, particularly at the local level, is needed to determine the most efficient institutional approach to the resolution of flooding problems.

23. A detailed institutional analysis of the subbasin is needed.

24. A detailed social profile of the subbasin is needed.

25. Urban damages need to be recomputed in a systematic fashion.

26. A review of secondary sources and systematic field reconnaissance is needed to identify archaeological and historical sites and to determine their eligibility for nomination to the National Register of Historic Places.

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Appendix A
FLOODPLAIN DELINEATION

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FLOODPLAIN DELINEATION

Prior to this study, no attempt was made to publish even a generalized delineation of the entire Pembina River floodplain. In undertaking this task, the present study utilized all known sources to provide the best available data for generalized delineation of the U.S. portion of the subbasin at a scale of 1:250,000. Principal sources were: USGS Flood Prone Area Maps (scale 1:24,000), Corps of Engineer photomosaics of the 1979 flood, published secondary sources, U.S. Geological Survey (USGS) 7 1/2 minute topographic maps, and other sources, including derived data where necessary.

Like other Red River subbasins, the 100-year floodplain was delineated as a composite of available sources. The Flood Prone Area Maps published by the USGS provided detailed and highly accurate information for the area mapped. Seven sheets in the eastern portion of the subbasin provided excellent coverage based on 1974 and 1975 data. Three sheets in the Walhalla-Langdon area provided valuable, but less extensive, coverage of the central portion. One sheet east of the Turtle Mountains was available in the western part of the subbasin.

Photomosaics of aerial photography flown by the Corps of Engineers during the 1979 flood (100-year frequency) proved extemely valuable on the North Dakota side of the Red River Basin. These one inch equals 0.83 miles mosaics provided the framework information in much the same manner as the Federal Insurance Administration flood maps had done for the Minnesota side. Principal coverage was generally limited to the downstream areas in Pembina and eastern Cavalier counties.

Secondary sources, such as the Souris-Red-Rainy Basins Type II Study (delineating the main stem floodplain) were also utilized. Published floodplain descriptions and acreage estimates in the Pembina River Feasibility Report published in 1976 by the Corps of Engineers and other sources were consulted. U.S. Geological Survey 7 1/2 minute topographic maps of five relevant areas are also available. Federal Insurance Administration flood maps played only a minor role, since maps were available only for selected incorporated areas in Pembina and Rolette counties.

Where published information was lacking, as in the area between the Tongue and Pembina Rivers, the extent of the floodplain was inferred for abrupt endings on the photomosaics and placed on the USGS 250,000-scale maps with other information. The resultant floodplain was then planimetered by segment, with the figures converted to acres and rounded to the nearest 2,000 acres.

Appendix B

INVENTORY OF OUTDOOR RECREATIONAL PEMBINA RIVER SUBBASIN

Appendix B

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES[1]
PEMBINA RIVER SUBBASIN

Number	Name	Administration	Location	Acres	Campgrounds[2]	Playground	Athletic Field[3]	Golf Courses[4]	Boat Ramps	Picnic Tables	Beach	Pool	Trails[5]
1	School Section Lake NWR	Federal	Rolette Co. 16372W16 School Section Lake	680.0					X		X		
2	Armourdale Dam WMA	State	Towner Co. 16268W02 Armourdale Lake	23.0		1			1	4			
3	Rock Lake NWR	Federal	Towner Co. 16266W28 Rock Lake	5,507.0									
4	Pembina Hills WMA	State	Cavalier Co. 16458W32 Mt. Carmel	2,609.0									
5	Tetrault State Forest (a)	State	Cavalier Co. Walhalla	40.0									
6	Tetrault State Forest (b)	State	Pembina Co. Walhalla	389.0									
7	Martineau WMA	State	Pembina Co. 16355W15 Leroy	120.0									
8	Clifford WMA	State	Pembina Co. 16255W20 Leydon	80.0									
9	Tongue River WMA	State	Pembina Co. 16256W34 Leydon	334.3									
1	International Peace Gardens	State	Rolette Co. Dunseith	2,339.0	X						X		

-continued-

Appendix B (Cont'd)

INVENTORY OF OUTDOOR RECREATIONAL FACILITIES[1]
PEMBINA RIVER SUBBASIN

Number	Name	Administration	Location	Acres	Campgrounds[2]	Playground	Athletic Field[3]	Golf Courses[4]	Boat Ramps	Picnic Tables	Beach	Pool	Trails[5]
2	Frost Fire Mountain Ski Resort	Private	Pembina Co. Walhalla	90.0									
3	Walhalla Park	Municipal	Pembina Co. Walhalla	50.0	50	2	1			24		1	
4	Mt. Carmel Dam	County	Cavalier Co. 16359W27 Mt. Carmel	1,001.0						15	2		
5	Pembina Hills Ski Way	Private	Cavalier Co. Langdon	15.0									
6	Langdon Park	Municipal	Cavalier Co. Langdon	23.0	10		3			12		1	
7	Senator Young Dam	County	Cavalier Co. 16159W27 Olga	190.0							1		
8	Icelandic State Park	State	Pembina Co. Cavalier	220.0	75					160	1		3.5
1	Walhalla Country Club	Private	Pembina Co. Walhalla	160.0				9					
2	Pembina Golf Course	Municipal	Pembina Co. Pembina	45.0				9					
3	Walhalla Golf Course	Private	Cavalier Co. Walhalla	170.0				9					
4	Langdon Golf Course	Private	Cavalier Co. Langdon	88.0				9					
5	Cavalier Country Club	Private	Pembina Co.	153.0				9					

[1] Facilities included are those with 15 or more acres.

[2] Number of campsites.

[3] Number of fields.

[4] Number of holes.

[5] Number of miles.

Source: North Dakota State Parks and Recreation Department, Inventory of North Dakota Outdoor Recreation Facilities, 1979.

Gulf South Research Institute.

Appendix C
COMMENTS

Appendix C

COMMENTS

The purpose of this subbasin report was to provide an overview of the water and related resource problems and needs and to assess potential solutions. Toward this end, draft copies of this report were circulated to Federal, State, and local agencies and comments were sought.

This review resulted in complete and factual documentation. Thus, the study should serve as a building block for the timely completion of future water resource efforts within the subbasin. Further cooperative efforts are, however, needed to evaluate these tentative results and to develop potential solutions.

A distribution list and copies of the comments made with respect to the draft report are included as part of this appendix. Comments that resulted in specific modifications to the draft text are marked by an asterisk.

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT CORPS OF ENGINEERS
1135 U S POST OFFICE & CUSTOM HOUSE
ST PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:
NCSED-PB

26 August 1980

Mr. Mike Liffmann
Project Manager
Gulf South Research Institute
8000 GSRI Avenue
Baton Rouge, Louisiana 70808

Dear Mr. Liffmann:

The draft Pembina River subbasin report was distributed for review and comment. Most of the reviewers have sent their comments to us.

a. Inclosure 1 includes letters from various Federal and State agencies. Other letters, when received, will be provided under separate cover.

b. Inclosure 2 is the general office comments that need to be considered when preparing the final Pembina River subbasin report and the remaining subbasin reports and the overall document.

c. Inclosure 3 identifies specific office concerns that are applicable to the Pembina River subbasin report.

If you have any questions on our comments or proposed modifications, please contact us.

Sincerely,

for LOUIS E. KOWALSKI
Chief, Planning Branch
Engineering Division

3 Incl
As stated

United States Department of Agriculture
Soil Conservation Service
P. O. Box 1458
Bismarck, ND
58502

July 16, 1980

Colonel William W. Badger
District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

Following are our comments concerning the Red River of the North reconnaissance study for the Pembina River Subbasin:

* Page 18, under the Hydropower Section, second sentence - Six dams should be changed to ten dams or more. There are ten dams built for flood control, recreation, etc. on the Tongue River.

* Page 26, under the Land Use Section, last sentence - Add the City of Cavalier. Also, in North Dakota all incorporated communities are called cities not towns. This error is in many places throughout the report.

Page 60, second paragraph - The discussion of land treatment is misleading. The SCS, through the Soil Conservation Districts, provides technical assistance to landowners on a voluntary basis. The statement that SCS has not been called upon to undertake a large-scale program needs to be further defined or eliminated.

We appreciate the opportunity to review and comment.

Sincerely,

Charles E. Mumma
Assistant State Conservationist (WR)

United States Department of the Interior
FISH AND WILDLIFE SERVICE
AREA OFFICE—NORTH DAKOTA
1500 CAPITOL AVENUE
P.O. BOX 1897
BISMARCK, NORTH DAKOTA 58501

AUG 11 1980

Colonel William W. Badger, District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Re: Red River Mainstem (CE)

Dear Colonel Badger:

This provides U.S. Fish and Wildlife Service (FWS) comments on the Draft Reconnaissance Report recently compiled by Gulf South Research Institute for the Pembina River Subbasin in Rolette, Towner, Cavalier, and Pembina Counties in North Dakota and Manitoba Province in Canada.

Generally, we believe the draft report to be well written and it provides a good overview of the water and related land resources, problems and potential solutions to some of these problems within this subbasin of the Red River of the North.

Our major concerns are associated with the woodland, wetland, grassland, riverine and riparian flood-plain habitats that continue to exist within the Pembina River Subbasin. We are particularly concerned with remaining woodlands found within the Turtle Mountains, Pembina Hills, and along the Pembina River and its tributaries. We agree (as stated on pages 13-14 and 42), that these woodland areas are significant because of their value as wildlife habitat and because much of the area's woodland vegetation has been cleared for agricultural production. These remaining areas, in many instances, provide the only available habitat left for wildlife within this heavily farmed area of northeastern North Dakota and function as important migrational corridors for deer, small mammals, birds and many other forms of wildlife. The continued removal and conversion of these riparian and other woodland habitats to cropland will adversely impact the wildlife species that presently use these areas. We fully agree with the statement on page 14 of the report that there is a need to protect, conserve and, if possible, enhance the remaining woodlands of the Pembina River Subbasin.

Several factors that contribute to the size and duratio of spring floods were listed on page 7. Those listed included snow depth, subsurface frost depth, spring temperatures, and rainfall. We agree. However, a study conducted by FWS (Kloet 1971) entitled "Effects of Drainage on Runoff and Flooding Within the Pembina River Basin, North Dakota-Manitoba" showed that flood peaks after 1942 were significantly higher than those prior to 1942. (Overall average precipitation was similar for both time periods.) It was concluded that higher flood peaks after 1942 resulted from either wetland drainage or changes in agricultural practices or a combination of both. The FWS believes that wetland drainage and more intensive agricultural land-use practices are also factors affecting the intensity of spring flooding in the subbasin.

We agree with the statement on page 78 that additional studies will have to be undertaken and additional information obtained on this subbasin to provide a more detailed and indepth analysis of subbasin resources, problems, and potential solutions.

The report addressed six structural alternative measures that have been identified to date to meet the study's flood damage reduction objective. These measures and our comments relative to each are as follows:

Alternative 1 (Pembilier Dam and Reservoir)

This alternative recommended in the Corps of Engineers (CE) Feasibility Report and authorized by Congress for additional study is the Pembilier Dam and Reservoir. The proposed dam would be an earthen structure, 150 feet high and 2,100 feet long, located on the Pembina River about 2 miles upstream of Walhalla, North Dakota. The reservoir would have 147,000 acre-feet of storage, of which 15,000 would be for sedimentation, 4,000 for recreation and water supplies, and 128,000 for flood control. The conservation pool would cover 800 acres, while the flood pool would be 3,200 acres in size. Construction of this dam and reservoir would have significant impacts on the vegetation and wildlife found in the river valley (FWS April 26, 1976, report to the CE, St. Paul District). The recommended plan included 16,000 acres of land for wildlife mitigation to offset loss of wildlife habitat in the reservoir area and downstream from the dam. About 2,800 acres of project lands would be in the wildlife management area and 13,200 acres would be acquired solely for wildlife mitigation. To accommodate recreation, 1,000 acres outside the regular project boundary would be purchased and developed.

The Board of Engineers for Rivers and Harbors disagreed with the Habitat Evaluation Procedures (HEP) methodology used as basis for determining wildlife mitigation needs and recommended that the area identified as separable wildlife mitigation lands be excluded from the proposed project. The Chief of Engineers concurred with this recommendation. The need for, and extent of, wildlife mitigation was to be determined during Phase I studies. For this reason and because of inadequate coverage of outdoor recreation needs, the Department of the Interior in its letter of comment dated August 15, 1977, found the Chief's report to be unacceptable. The FWS agreed to participate in a Phase I GDM Study of the Pembina River Subbasin in Fiscal Year 1980. The study was to be a modified reformulation of Pembilier Dam and several alternative plans. Impacts of each of the plans on fish and wildlife resources would have been determined by application of the new 1980 HEP methodology. The study was halted due to an apparent lack of funding for Fiscal Year 1981. This project would be considered acceptable to the U.S. Fish and Wildlife Service only if the unavoidable adverse impacts of the project on fish and wildlife resources are adequately compensated.

Alternative 2 (Pembilier Dry Dam)

The dry dam would occupy the same physical site as that proposed for the multiple-purpose dam. There would be no permanent reservoir, and water would be stored only as needed to prevent or minimize downstream flooding during high flows. With the absence of the 800-acre permanent lake, the dry dam would result in less immediate damage to the river and the surrounding land. Also, with no permanent storage and less sediment trapped by the dam, the level of flood protection would be higher for the same height of dam or the height of the dam could be reduced a few feet without sacrificing downstream flood protection.

Long-term environmental effects associated with this alternative would depend largely on the degree and frequency with which the storage capacity would be used. A wildlife mitigation plan has not been formulated for this alternative. Periodic impoundment of flood flows and deposition of silt would affect vegetation in the flood pool. For the design flood, about 3,100 acres of wildlife habitat would be affected. Neither water supply nor lake-oriented recreation would be provided.

Alternative 3 - Urban Levees (Neche)

This measure would provide 1 percent (100-year) flood protection for Neche and would be implemented by the CE. Environmental impacts of the local protection facilities contemplated for Neche are likely to be minor, especially if levees are placed outside wooded areas.

Alternative 4 - Boundary Floodway

The boundary floodway alternative would consist of a small diversion dam about 3 miles downstream from Walhalla. It would permit normal flows in the natural river channel, but would divert flood flows into a floodway. The floodway would proceed north to the International Boundary and than directly east for a distance of about 30 miles to the conjunction with the Red River of the North just downstream from Pembina.

At the design flow of 6,300 cfs (a 9-year frequency flood), 3,000 cfs would be allowed to pass down the normal river channel and the remaining 3,300 cfs would be diverted into the floodway. The design flow would flood about 600 acres directly upstream from the diversion structure. It would be necessary to purchase 1,100 acres of land upstream of the diversion structure so that no private land would be inundated because of the diversion structure. In addition, 1,000 acres would be necessary for the floodway channel and 1,400 acres would be needed to accommodate excavated material from the channel. Five highway bridges and six drop structures would have to be constructed. Farm crossings across the channel would be provided wherever possible. The floodway would be designed so the flooding would not be worse than normally expected when the 9-year design flood is exceeded. Most of the land above the diversion structure and the floodway is cropland. They would be seeded to grass. This alternative is less costly than Alternatives 1 and 2 and has a favorable B/C ratio, although not as favorable as that calculated for Pembilier Dam and Dry Dam. A wildlife mitigation plan has not been formulated for this alternative. However, expected mitigation would be minor. The boundary floodway is a much more environmentally sound plan.

Alternative 5 - Channel Improvements/Pembina River Watershed

The locations of proposed channel improvements were not identified in the report. However, in our view, channelization projects constitute, in most instances, short-term, piecemeal, and localized attempts to reduce flooding problems that disregard effective long-range solutions and place an added burden of floodwaters on people and property downstream. If undertaken, channel modification should be the minimum required, in combination with other measures, and accomplished using the least damaging construction techniques and equipment to preserve as much of the existing characteristics of the river channel and associated riparian habitat as possible. These construction practices should include such measures as maintaining existing stream meanders, grading and reshaping only in steep bank and other severe erosion problems areas, minimizing cutting or removal of adjacent riparian vegetation, depositing all excavated, dredged or other excess material on an appropriate upland site rather than in low flood-plain or adjacent land areas, and promptly reseeding all disrupted areas following construction. Finally, any adverse impact resulting from unavoiable flood-plain or wetland encroachment should be compensated for by reestablishment of lost or enhancement of existing flood-plain values. In the past, stream modification alternatives in the Prairie Pothole Region of western Minnesota and eastern North Dakota facilitated the drainage of existing wetlands in addition to those already drained within the project area. It is the FWS's belief that wetland drainage, both legal and illegal, is one of the principal causes for the increased frequency of flooding in the Red River Basin today.

Alternative 6 - Farmstead Levees

We do not anticipate any significant adverse environmental impacts due to this alternative provided that the dikes are not constructed through wetland areas and impacts to existing woodland vegetation are avoided to the extent possible.

In addition, we suggest that the following changes be made in the final report:

*1. Page 33, 2nd paragraph, 2nd sentence - We suggest this sentence be changed to read:

> The Little South Pembina reach from the headwaters to Mt. Carmel Dam has a critical value for serving as a water supply for Mt. Carmel Dam. In 1978, Mt. Carmel Dam supported an excellent trout fishery. However, due to increased eutrophication from agricultural runoff, Mt. Carmel Dam presently only supports a northern pike and walleye sports fishery.

*2. Page 46, 1st paragraph under the heading "Natural Areas" - Change this paragraph to read as follows:

> Kantrud (1973) listed 11 natural areas that are located within the Pembina River Subbasin. Two of these (the Little North Pembina Gorge and the Tongue River Gorge) are located in the eastern portion of Cavalier County. These two sites offer a

scenic overview, as well as habitats for wildlife such as the scarlet tanager, lynx, northern waterthrush, ovenbird, and moose. The other nine natural areas are scattered throughout Pembina County: (1) Black Ash Woods, (2) St. Joseph Woods, (3) McLarty Grove, (4) Akra Grove, (5) Tongue River Game Management Area (GMA), (6) Clifford GMA, (7) Icelandic State Park, (8) Foxen Grove, and (9) Tetrault State Forest. All of these sites are comprised of bottomland hardwoods that have a high biological productivity. Species known or presumed to occur in these areas include lynx, timber wolf, false spikenard, ruffed grouse, and scarlet tanager. Additionally, the McLarty Grove area contains American elms up to 4.5 feet DBH (diameter at breast height) and 100 feet tall (Kantrud 1973). See Figure IV for approximate locations of these areas.

*3. Page 49, Figure IV - Add the locations of (1) Tongue River GMA, (2) Clifford GMA, (3) Icelandic State Park, (4) Tetrault State Forest, and (5) Foxen Grove.

*4. Page 78 - Add riparian woodlands to Recommendation No. 2.

We would appreciate more response time to adequately review and provide our comments on future draft reports on the subbasins of the Red River of the North. We believe a 1-month response time would be appropriate for each individual subbasin report.

These comments have been prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and are consistent with the intent of the National Environmental Policy Act of 1969.

The opportunity to review and comment on the Draft Reconnaissance Report for the Pembina River Subbasin is appreciated.

Sincerely yours,

Gilbert E. Key

Gilbert E. Key
Area Manager

U.S. Army Corps of Engineers

North Central Division

Comments on the

Draft Pembina River Subbasin

June 1980

Cmt. No.	Comment
1.	Figure II is a poor map cartographically. There needs to be a legend which clearly describes the patterning used to delineate the 100-year floodplain, marshy areas, etc.
2.	Would suggest modifying the explanation of nonstructural measures. Would suggest incorporating the following thoughts: Nonstructural measures modify the susceptibility of land, people, and property to damage or losses. In addition, they modify the impact of flooding upon people and communities. Nonstructural measures do not attempt to modify the behavior of floodwaters.
3.	Add a discussion of the National Objectives (NED & EQ) as established by P & S.
4.	The list of objectives is basically good but awkwardly written. Would suggest rewriting such as below. Enhance the recreational opportunities in the Pembina River subbasin for the benefit of the local people.
5.	The assessment and evaluation sections need to emphasize how each alternative meets or doesn't meet each objective both study objectives and National Objectives.
6.	Page 16. Recreation Problems. This discussion equates lack of recreation opportunities with scarcity of natural lakes. It may be desirable in the end to enhance existing natural resources, such as streams and woodlands, to benefit hiking, camping, and fishing. The perception of "recreation" needs to be broadened.
7.	Page 18. Erosion Problems. Should consider the natural benefits gained from sediment deposition on the floodplain.
8.	Page 64, 1st para. The last sentence requires clarification. Flood control measure(s) will be a necessary component of any plan that is recommended under this authority (with the exception of the no action plan): however, other measures addressing other objectives may be included in a plan regardless of whether or not these measures provide flood damage reduction.

Cmt. No.	Comment
9.	Page 66(2). Since public water supply and recreation benefits could be derived from the multipurpose reservoir plan but not from the dry dam plan, it would appear that the average annual benefits of the two plans would not be "about the same".
10.	Pages 70 and 77. The Assessment and Evaluation sections should have stated that the amount of information required to conduct even a preliminary evaluation of additional measures (i.e.,land treatment measures, preservation of natural retention areas, and wetland restoration is not available at this stage of study.
11.	Page 77. It is not necessary, or advisable, to identify an NED Plan and EQ Plan at this stage of study. The amount of information necessary to formulate all alternatives is not available at this point in time.
12.	Page 64. Discuss the multipurposes of Pembilier Dam in more specific terms such as type of recreation to be provided; i.e. swimming, boating, etc. Also, what area will be served by the water supply and what portion of the storage will be allocated for these purposes?
13.	Page 71. As a basis of comparison with other alternatives, indicate the design level of protection for alternative 5.
14.	Page 71. Alternative 6. The costs for farmstead levees will vary considerably depending on size of farmstead; number, type, and composition of outbuildings; access road elevation: and level of flooding. As more detail is developed for this study, include the total costs and benefits, on a regional basis, for constructing farmstead levees.
15.	Page 71. Alternative 3. As a minimum discuss the feasibility of other alternatives through the urban areas such as channelization of various levels of protection, channel diversion around the damage center, and nonstructural relocation of structures in the floodway.
16.	The impact of floodplain valley storage loss on flooding through project levee construction needs to be analyzed in future studies.
17.	Future studies must consider the coincidence of flooding due to Red River proper.

Cmt. No.	Comment
18.	Page 50. The discussion notes that unusual circumstances have occurred in Pembina County and due to these disruptions the historical trend is not valid for projecting (or to use as a guide or a check) future population, employment, and income levels. Since these disruptions are characterized as severe, it is recommended that the effect of the disruptions be described in detail. Include additional data in the expanded analysis of the economic disruptions.
19.	Page 51, Table 14. Due to the severe economic disruptions which occurred in the area during the 1970's, add 1950 and 1960 data to the table.
20.	Page 77. The EQ alternative, which has a B/C ratio of 1.15, is not discussed in the text. Include a description of this alternative (which appears to draw elements from the other alternatives) in the "Formulation of Alternative Measures" section and discuss the EQ alternative in the "Assessment of Alternatives" section as well as include a row for this alternative in table 17.

[redacted]
[redacted]
[redacted]
[redacted]

July 16, 1980

William W. Badger
Colonel, Corps of Engineers
District Engineer
Department of the Army
St. Paul District Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

RE: Red River Mainstem Study - SWC Project #1701

Dear Colonel Badger:

This letter is to provide comments on the draft report on the Pembina River, for the Red River of the North Reconnaissance Study. Attached are copies of pages from the report with pencilad comments. Although some of these comments are editorial, others do relate to the content of the report.

Overall, we are satisfied with the report, although we recognize that the report was specific to the flood control problem. As was mentioned in the March 3, 1980 letter on the study, we had hoped that solutions for total water management could have been developed. This is something that should be addressed in the final Basin report.

Throughout the report GSRI is mentioned as a source for data. If this is new data, it should be noted as such. If it is updated data, the method for updating should be described. Since this report will be used as a reference in the future, it is necessary to better explain how the data was derived, or what the source is. Although several references are listed, footnotes were not used, which makes information source identification impossible.

Apparently GSRI is not aware of the Pembina County and Cavalier County Groundwater Studies. Data from these reports could be used for groundwater aquifer identification.

On page 74, the statement is made that "Several endangered species could be affected, and there is a likelihood of eutrophication after impoundment". Since this statement can not be substantiated, I do not believe it should be in the report.

Sincerely yours,

Dale F Sprinkle
for

David A. Sprynczynatyk, P.E.
Director, Engineering Division

DAS:dm

cc: Gene Krenz
Director of Planning

GULF SOUTH RESEARCH INSTITUTE
P.O. Box 14737 Telephone Area Code 504 766-3300 Baton Rouge, Louisiana 70898

June 1980

Draft Report

Contract No. DACW37-80-C-0017
GSRI Project No. 955

RECONNAISSANCE REPORT:
RED RIVER OF THE NORTH BASIN
PEMBINA RIVER SUBBASIN

Prepared for:

U.S. Army Corps of Engineers
St. Paul District
St. Paul, Minnesota

III. PROBLEMS, NEEDS, AND DESIRES

The primary water-related problems, needs, and desires in the Red River Basin are flood control, fish and wildlife conservation and enhancement, recreation, water supply, water quality, erosion control, irrigation, wastewater management, and hydropower. Various water-related problems, needs, and desires have been identified for the Pembina River Subbasin in previous planning reports on the basis of analysis of conditions and public and agency comments. The list of problems, needs, and desires for the subbasin is the same as the list for the Red River Basin as a whole, with the exception of hydropower. Each problem is discussed separately below, with an emphasis on flooding problems.

Flooding Problems

Nature of the Problems

An important aspect of the flooding problem is that the topography of the subbasin does not generally produce high flows. The large percentage of the area that is poorly drained, together with areas that have no drainage, reduces the magnitude of the flood flows below that which might normally be expected from such a large drainage area. In some parts of the subbasin, however, steep valley slopes do produce rapid runoff.

Flooding along the Pembina and its tributaries nearly always occurs during the spring as a result of rapid snowmelt, sometimes accompanied by rainfall, or from heavy spring rains following snowmelt when conditions are especially favorable for high runoff. Factors affecting the size of spring floods include: the amount of snow on the ground (one to 2½ feet are common), the depth of frost underground, temperatures during breakup, and the occurrence of spring rains. The latter have been known to prolong some of the snowmelt floods or cause subsequent floods after snowmelt runoff. Such floods usually lead to delays in planting operations and result in reduced crop yields.

Unlike other Red River subbasins, general summer storms do not often occur over large areas of the subbasin. Consequently, floods are rare in the summer months, although some increased streamflow does occur.

No known floods have occurred in the fall or winter months. In addition, lakes in the upper valley, in effect, retard runoff from the area above their outlets so that flood peaks downstream are reduced.

Two separate types of flooding occur: the most damaging type associated with river bank overflow (overbank flooding) and another type caused by runoff from snowmelt or heavy rainfall impounded by plugged culverts and ditches within sections of land bounded by roadways on earthen fill (overland flooding). In overland flooding, the trapped water slowly accumulates until it overflows the roadways and inundates section after section of land as it moves overland in the direction of the regional slope until reaching river or stream channels.

As discussed in the following section, damaging floods generally occur primarily east of the Pembina Escarpment. In this area the land is very flat and banks are low, enabling flows to inundate considerable areas. Prior to the construction of border dikes in U.S. and Canada, a reduction in peak flows between Walhalla and Neche always occurred because of the overland escape of waters into other watersheds.

Flows are also restricted by snags, fallen trees, debris, and slides caused by undermined trees. In addition to such localized flooding, flood flows contribute to the overall magnitude and duration of flooding on the main stem Red River. The Pembina drainage in the U.S. area accounts for 5.0 percent of the total basin and just over 10 percent of the total Red River flow at the international boundary.

Location and Extent

Figure II depicts the 100-year floodplain for the subbasin. Prior to this study, no attempt had been made to publish even a generalized delineation of the entire area. A number of sources were investigated in order to produce the present delineation. Among these were: (1) U.S. Geological Survey (USGS) Flood Prone Area Maps at 1:24,000 scale; (2) Corps of Engineers photomosaics of the 1979 flood; (3) published secondary sources describing flooded areas; and (4) USGS 7½ minute topographic maps.

The map is thus a composite of available sources supplemented by inferences where necessary. Because the sources were incomplete and

Flood Damages

The primary areas affected by flooding throughout the subbasin's floodplain are urban, agricultural and environmental in nature. The towns of Pembina, Neche, and Walhalla are the urban areas in the floodplain of this subbasin. The only damage categories taken into account in the computation of average annual damages are urban and rural.

Present average annual damages in the subbasin are estimated at $2.8 million. This is one of the largest average annual damage figures in the entire basin, accounting for eight percent of the Red River of the North basin-wide total. Average annual damages are separated into two basic classifications: urban and rural. Damages to residences, businesses (commercial and industrial) and public facilities (streets, utilities, sewers, etc.) are reported as urban damages. Damages to crops, other agricultural assets (fences, machinery, farm buildings, etc.) and transportation facilities are reported as rural damages. Rural damages account for 94 percent of the total average annual damage figure for the subbasin, and urban damages account for the remaining six percent.

Urban flood damages sustained during the 1979 flood event amounted to $205,000. No urban flood damages were reported to have resulted from the 1975 flood event. Average annual urban flood damages in the subbasin are estimated at $162,800. A more detailed breakdown of these urban flood damage figures is presented in Table 1. Urban damages resulting from the 1979 flood event included $102,500 in residential damages, $82,000 in damages to businesses, and $20,500 in public damages. Average annual urban flood damages are estimated at $81,400 in residential damages, $65,100 in business related damages and $16,300 in public types of damages.

Average annual rural flood damages and the rural flood damages incurred in the 1979 flood event are shown in Table 2. Rural flood damages sustained in the 1979 flood event included $4.6 million in crop damages, $660,000 in other agricultural damages and $340,000 in transportation damages. In comparison, average annual rural flood damages are estimated at $1.8 million in crop damages, $600,500 in other agricultural damages and $227,800 in transportation damages. Total rural flood damages were $5.6 million in the 1979 flood event and $2.6 million on an average annual basis.

Environmental Concerns

The Souris-Red-Rainy River Basins Commission (1972) reported that the state of North Dakota has a smaller percentage of woodlands than any of the 50 states, with a total of about 400,000 acres of natural timber. The Commission indicated that the Turtle Mountains in the Souris River Basin and the Pembina Hills and Devils Lake area in the Red River Basin constitute the most important remaining areas of natural woodlands. Approximately 252,000 acres of forest remain in these three areas. These areas are considered even more significant now because the construction and filling of Garrison and Oahe Reservoirs and extensive clearing between these two lakes has reduced major bottomland hardwood formations along the Missouri River. The forests in the three areas provide high-value habitats for wildlife and for outdoor recreation associated with wildlife and are excellent aesthetic attractions.

The Commission indicated further that about 35 percent of the forests in the three abovementioned areas had been cleared in the past 20 years. Although the State provides tax abatements for woodland maintenance, the clearing has not been reduced. Further, the native timber in these areas has little market value, and landowners are, apparently, not provided with an adequate incentive to save them ~~on this basis~~. The U.S. Army Corps of Engineers (1977a) stated that annual rates of clearing for Pembina, Cavalier, Towner, and Rolette counties during 1958-1967 were 1.0, 3.6, 3.4, and 0.1 percent, respectively.

Table 3 provides data on the woodland acreages remaining in the Turtle Mountains, Upper Pembina Valley, and Devils Lake areas. The table shows that 28,200 acres of woodlands are in public ownership; the remaining 223,800 acres are privately owned and subject to clearing. The Souris-Red-Rainy River Basins Commission (1972) reported that a ten-year program, involving the State Forest Service, State Park Service, and State Game and Fish Department, could be developed to acquire the remaining woodlands. The State Outdoor Recreation Agency, State Highway Department, and State Water Commission would provide important technical, engineering, and legal assistance.

Table 3

WOODLAND PRESERVATION AREAS IN NORTH DAKOTA

Area	Existing Woodland (Acres)	Publicly Owned Woodlands (Acres)	Woodlands Remaining to Be Acquired to Assure Preservation of the Area (Acres)
Souris River Basin			
Turtle Mountain*	125,000	20,700	104,300
Red River of the North Basin			
Upper Pembina Valley	84,000	5,770	78,2?
Devils Lake Area	43,000	1,730	4?
TOTAL	252,000	28,200	

*An undetermined amount of acreage in this area falls within th River Subbasin.

Source: Souris-Red-Rainy River Basins Comprehensive Study, Appendix . Fish and Wildlife.

The U.S. Army Corps of Engineers (1977) indicated that the Deputy State Forester emphasized the need for the State to concentrate its forestry efforts in Pembina and Cavalier counties, where the largest contiguous blocks of native forest remained and where maximum results could be expected. These two counties, along with Walsh and Grand Forks, were considered to have the greatest rate of clearing in the state and had lost 27,897 acres, or 27 percent of their 1956 forest land base acreage, to agriculture. Woodland losses have proceeded at the rate of about three percent each year and have involved approximately 76,000 acres, 90 percent of which was in the Pembina Subbasin.

The information presented above indicates the pressing need to protect the remaining woodlands of the subbasin, since they are extremely significant habitats for wildlife, are important for wildlife-oriented recreation, and are of exceptional aesthetic value.

of shallow water and high BOD. Most other lakes in the subbasin do not support year-round fish populations because of shallow water conditions. Rainbow and brown trout have been stocked in Renwick Reservoir and below the dam, but recurring winter kill conditions presently prevent success of this program. Upstream fish movements are prevented between Walhalla and the confluence of the Tongue River and the Pembina River during normal flow by the presence of two low-head dams. However, the fish are able to move past these obstructions during the high water period (spring runoff), when the dams become submerged (U.S. Army Corps of Engineers, 1977a).

Aquatic vegetation is lacking in most areas, probably because of high flows, silt deposition, scouring during spring runoff, and low flows at other times of the year. Periphyton is nearly absent on suitable substrates such as rocks because of a silt coating (U.S. Army Corps of Engineers, 1977a).

Recreation Problems

Recreation problems in the subbasin stem from the scarcity of natural lakes. Recreation opportunities are particularly limited in the western portion of the subbasin and in the level area east of the escarpment.

The fishing potential of the lower reaches of the Pembina, Tongue, and Little Pembina rivers has been limited by intermittent flows and water quality problems as a result of municipal effluents and agricultural runoff discharged into the streams. Most of the natural lakes and several artificial impoundments in the subbasin are subject to severe winter and summer kill conditions.

The 1975 North Dakota State Comprehensive Outdoor Recreation Plan identified primary needs in the area as swimming, boating, hiking, fishing, and camping. Snow-skiing and snowmobiling are the primary winter activity needs.

Water Quality Problems

The water quality in the Pembina River is considered good. Problem parameters include low dissolved oxygen, high nitrates, and high phosphates. Intermittent flows also create water quality problems such as decreased

Erosion Problems

Soil damage in the subbasin includes bank erosion, sheet erosion and sediment deposition. The most significant concern relating to sedimentation is during major flood overflows. The floodwaters deposit sediment on the floodplain, causing substantial delays in planting and adding to treatment costs for nuisance weeds. Floodplain erosion in certain areas has scoured and removed rich topsoil resulting in long-term reductions in soil fertility. Sheet and gully erosion add to the sediment load of the river. Slumping can be a problem where cultivated fields or structures encroach on the rivers.

Irrigation

Although irrigation practices are increasing in North Dakota, most of the irrigation takes place outside of the Red River Basin. The subbasin is located within North Dakota's Planning Region IV and the North Central Region, and it includes the counties of Pembina, Cavalier, Towner, and Rolette. The irrigation potential within each of these counties is unknown because the ground water resources have not been fully investigated.

Wastewater Management

The water quality of Pembina River is reduced by high concentrations of nitrates and phosphates which enter the stream from agriculture-related non-point sources. These pollutants impair recreational, fishery, wildlife, and stock watering uses on the river (North Dakota Statewide 208 Water Quality Management Plan, 1978). The point sources, especially municipal sewer treatment facilities, appear to be adequate. Table 5 lists nine communities, and their respective treatment facilities located in the subbasin.

Hydropower

As early as 1845, the Pembina River was used for water power when a mill dam was constructed at the foot of the Pembina Escarpment. Since that time, six dams have been constructed on the Pembina and Tongue rivers within the subbasin. These facilities were built primarily for flood control purposes, recreation, or additional water supply, and not for hydroelectric power generation. The existing dams and their present

As discussed in the flooding problems section, the construction of dikes on both sides of the international boundary is of considerable concern to area residents. By preventing natural overland flows into other watersheds, the dikes have changed existing flow conditions and worsened local flooding conditions.

Additional evidence for interest in flood control measures is contained in public hearings held in East Grand Forks in 1978 and 1979 before subcommittees of the Committee on Public Works and Transportation of the U.S. House of Representatives. From these documents, it is evident that residents of the Red River Basin consider flood control to be the primary water related need for the area and that they are interested in whatever solutions may be proposed by Federal, state, or local agencies.

and 89 percent, respectively, living in the same county. In Cavalier and Towner counties, 71 percent and 69 percent lived in the same residence since 1965, and 91 percent of the Cavalier population and 88 percent of the Towner population lived in the same county. The number of people living and working in the same county ranged from 83 percent in Cavalier County to 92.9 percent in Rolette County.

Economic Characteristics

Employment

For the past 30 years, agricultural employment in the subbasin has been decreasing. The decline in farm jobs was primarily due to the decreasing number of farms and the increasing substitution of machinery for farm labor. Employment in trade, manufacturing, and other nonfarm activities increased slightly during the same time period, but the increases were not substantial enough to compensate for the rapid decrease in farm employment. As a result, there was a decrease in total employment.

During the 1970's most nonagricultural employment sectors continued to increase. Employment in the government sector was greatly influenced by the development of Anti-Ballistic Missile (ABM) system facilities in Cavalier and Pembina counties. Although these facilities were deactivated in 1976, employment ranged from 1,500 to nearly 4,000 between 1969 and 1976. By 1978, employment had been reduced, which created readjustment needs. The result of the fluctuations in the various employment sectors was an increase in total employment. Employment in the subbasin increased from 5,091 in 1970 to 6,692 in 1977, which was a 31 percent increase. The agricultural sector will continue to be the largest employment sector, followed in importance by trade, services, and manufacturing.

Unemployment in the subbasin averaged about seven percent during the 1970's. During the winter months when farm and construction activity is minimal, unemployment is very high. During the spring planting, unemployment decreases and continues to do so until after the fall harvesting.

Income

Total personal income for the subbasin increased from $75 million to $85 million between 1969 and 1977 (expressed in 1979 dollars). Farm

Transportation Network

The subbasin is crossed from north to south by State highways 20, 1 (through Langdon), 32 (through Walhalla), and 18 (through Neche) and by U.S. 81 (through Hamilton) and Interstate 29, near the town of Pembina. Each of the state highways runs south and intersects U.S. 2, which is a direct route to Grand Forks. Highway 81 and Interstate 29 are located in the far western part of the subbasin, and both run south directly to the cities of Grand Forks and Fargo. The major east to west highway is State Highway 5, which runs through Langdon, Cavalier, and Hamilton and provides a connection to U.S. 81 and Interstate 29.

The Burlington Northern Railroad has seven railway lines which traverse the subbasin from north to south and provide service into the city of Grand Forks. These lines pass through most of the towns in the subbasin. The Soo Line Railroad has one rail line in the western part of the subbasin. There are municipal airports with hard-surfaced runways located in Pembina, Walhalla, and Cavalier. A few other airports in the subbasin have turf composition runways offering limited service. A pipeline carrying crude oil from western Canada to Buffalo, New York crosses the northeastern part of the subbasin, and a pipeline carrying natural gas crosses the southwestern part of the subbasin.

Land Use Source?

Approximately 80 percent of the subbasin is cultivated, seven percent is pasture, almost six percent is forest, and 1.9 percent is urban. Only one percent of the total land area is composed of water or marsh areas.

The floodplain is an important agricultural area. Most of the land in the floodplain is under cultivation. The towns within the floodplain include Neche, Walhalla, and Pembina.

Environmental Characteristics

Climate

Weather information is obtainable from U.S. Weather Bureau stations at Cavalier, Langdon, and Pembina. The subbasin has a continental climate that may be classified as "cool temperate subhumid." The area is characterized

require additional treatment of effluent other than required for Class I streams (Shewman and North Dakota State Department of Health, no date). Table 9 presents water quality data from two stations on the Pembina River and one station from the Little South Pembina River. The data presented in the table indicates that the phosphate standard is almost consistently violated. Additionally, sulfates, nitrates, TDS, fecal coliforms, dissolved oxygen, and pH are sometimes reported in extreme conditions and occassionally are in violation of the standards. Many of the major pesticides (such as DDT, lindane, heptachlor, toxaphene, 2,4-D, and chlordane) were tested for during the same samplings at these stations. No pesticides were discovered from any of the samples (U.S. Geological Survey, 1979).

Table 9

SURFACE WATER QUALITY DATA FROM THREE RECORDING STATIONS ON THE PEMBINA RIVER, OCTOBER, 1977 TO SEPTEMBER, 1978

Parameter	Standard[1]	Vang		Walhalla[2]		Walhalla	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Stream Flow (CFS)	--	0.01	1,500	0.28	1,190	0.11	3,360
pH (Standard Units)	7-8.5	7.2	8.5	7.4	8.3	7.1	8.3
Temperature (°C)	31	0.0	25.5	0.0	22.5	0.0	25.0
Dissolved Oxygen (D.O.)	5.0 (Min)	0.5	12.6	7.4	13.2	6.4	13.0
Fecal Coliform (#/100 ml)	200	11	3,100	33	1,200	<1	280
Hardness ($CACO_3$)	--	640	120	120	390	220	490
Sulfate	--	280	82	74	250	110	260
Chloride	175	4.4	23	5.1	27	7.7	20
Fluoride	--	0.2	0.4	0.2	0.6	0.1	0.4
Total Dissolved Solids (TDS)	1,000	247	958	249	636	402	736
Nitrates (N)	4.0	0.22	5.4	0.00	3.6	0.01	3.0
Phosphates (P)	0.1	0.09	0.74	0.07	0.28	0.04	0.21
Iron (mg/l)	--	30	220	10	110	10	130

[1]From Shewman and North Dakota State Department of Health, No Date.

[2]Monitoring station located on Little South Pembina River near Walhalla.

Source: U. S. Geological Survey, 1979.

The Upper Mississippi River Basin Commission (1977) considered the groundwater supplies in the subbasin to be very limited. Presently, Rock Lake and Walhalla are the only municipalities that use groundwater exclusively

(429 acres), near Walhalla, Icelandic State Park (220 acres); and the International Peace Gardens (2,339 acres) near Dunseith. The Peace Gardens are on the Canadian border and attract an estimated 300,000 visitors annually.

Cultural Elements

Previous archeological-historical reconnaissances in the eastern part of the subbasin have indicated relatively few recorded archeological sites (Schneider, 1976; Ames, 1975). Here, as elsewhere in the Red River Valley, archeological resources are of a relatively late cultural context. Glacial Lake Agassiz inundated parts of the subbasin, and human occupation was not feasible until about 7000 B.P.? For sometime after the retreat of the glacial lake, the lacustrine plain remained poorly drained, somewhat swampy, and relatively unappealing to early prehistoric inhabitants.

Glacial beach ridges (strandlines) here, as throughout the Red River Valley, are often significant geological features and highly probable locations for occupation and mound sites (Johnson, 1962:126; Saylor, 1975:251). Other probable locations for archeological-historical sites include lake shores and stream banks.

The Pembina River region has played a significant role in the history of the Red River Valley. Historically, the region was inhabited by members of the Plains Chippewa, Cree, Assiniboine, and other nomadic Plains Indians. The earliest recorded European exploration of the Pembina region was associated with the development of the fur trade by a French Canadian (WPA, 1950:39). The subbasin soon became the scene of fierce competition and confrontation between the Hudson's Bay Company and the North West Company in a struggle for control of the fur trade.

By the late 18th and early 19th centuries, the North West Company and Hudson's Bay Company had established competing trading posts. The junction of the Red and Pembina rivers became the focal point for the control of trade. The Indians were soon drawn into the economic competition. Due to the influence of the fur trade, the Chippewa Indians had expanded as far west as the Turtle Mountains by 1820 (Hewes, 1948:49-50).

The Metis, a distinctive ethnic group of Indian-European heritage, were most active in the fur trade of the area. Most of the Metis were

which account for 99 percent of recreational acreage in the subbasin is presented in Appendix B of this report.

Hunting is a popular recreational activity in the subbasin. There are seven wildlife management areas in the subbasin west of the escarpment, including two National Wildlife Refuges in Rolette and Towner counties. A significant wildlife population exists in the subbasin, including white-tailed deer, moose, elk, grouse, partridge, and wild turkeys. Beaver and mink are the most important furbearers found within the subbasin.

Upstream reaches of the Pembina, Tongue, and Little South Pembina rivers provide excellent sport fishery, including northern pike, walleye, sauger, and channel catfish. Trout fishing is popular in the Little South Pembina River. The Pembina River has been identified for possible inclusion in the North Dakota system of wild, scenic, and recreation rivers.

It should be noted that the International Peace Garden is located in Rolette County and constitutes an important recreational asset to residents of the western portion of the subbasin. Improvements for Icelandic State Park and the multi-purpose project at Pembilier Dam, which includes plans for recreational development, are the only proposed sites identified in the subbasin. In addition, Johnson, Goschke, and Mount Carmel dams and Renwick Reservoir have been constructed in the area and serve as important bases of water and water-related recreational activity.

Significant Environmental Elements

Social

The towns of Pembina, Neche, and Walhalla are the urban areas most seriously affected by flooding problems. Several Corps of Engineer and Soil Conservation projects have been implemented which have alleviated flooding to some extent, but the above mentioned towns are still experiencing extensive problems. Damages caused to the towns by flooding include costs to repair residences, commercial establishments, transportation arteries, and utility lines. Damages to municipal water supplies or sewage systems may present health hazards.

The towns in the subbasin function primarily as agricultural service centers. As such, they suffer indirect economic losses because of the

losses incurred by farmers as a result of flooding, including delays in planting, damages to mature crops, farm structures and equipment, and the time needed to remove debris. It should be noted, however, that several flood control projects in the subbasin have been terminated because of lack of local support.

Cultural

Archeological resources in much of the subbasin might be expected to be of a relatively late cultural context because of geological conditions discussed previously. The subbasin has played a significant role in the history of the Red River Valley because early trade and agricultural settlement centered here. To date, only one historical site is listed on the National Register of Historic Places; but, as mentioned earlier, at least 15 have been tentatively identified from literary sources. The known and expected proximity of cultural resources to the Pembina River might be expected to affect the implementation of some flood control alternatives. These impacts are impossible to predict fully without a complete assessment of cultural resources in the subbasin.

Soils

The subbasin is divided into three district sections, with the Drift Prairie Plateau in the west and the Red River Valley in the east. A rugged strip of terrain, the Pembina Escarpment, separates the two plains regions. The Drift Prairie Plateau is mantled with glacial till composed of clays, sands, gravels and boulders. This region is made up of rolling undulating uplands, interspersed with flat areas, and the Pembina River Valley. Places in the uplands consist of irregular hills and depressions or potholes which are poorly drained or lie in undrained subbasins.

The area between the escarpment and the Red River of the North is flat with a gentle slope to the east. The Red River Valley soils consist of upper alluvial sandy silts and lower lacustrine clays overlying the deeply buried glacial till. Because of its fertile soil, this portion of the study area is regarded as one of the best agricultural areas. The silty clay soils are nearly all used for cultivated crops, but areas along streams are usually wooded or used for pasture.

Water

Only one percent of the total land area of the subbasin is occupied by water. This is one of the lowest percentages of water in the Red River Basin. However, streams such as the Tongue, Pembina, and Little South Pembina provide the subbasin with abundant fish populations which are very important to the recreational pursuits of trout and sport fishing.

Woodlands

The woodlands and brushy areas of the subbasin are considered significant because of their value as wildlife habitats, and, as explained in the Problems and Needs section, compose one of the most important areas of natural woodlands remaining in the State of North Dakota. In addition to their value as habitats for wildlife, they are important for wildlife-oriented outdoor recreation, and for their aesthetic appeal. It was further recognized under Problems and Needs that, during the period 1958-1967, clearing of private lands averaged more than three percent in Pembina and Cavalier counties, where most of these woodlands occur. There is a very real need to protect these habitats, as well as the floodplain forests in the eastern portion of the subbasin.

Wetlands

The wetlands of the subbasin are significant because of their many beneficial uses and values as habitats for flora and faunal development, waterfowl production, water storage during spring runoff and periods of extreme precipitation, groundwater recharge, sediment traps, and nutrient traps (Cernohous, 1979; U.S. Fish and Wildlife Service, 1979; E.O. 11990, dated 24 May 1977). They are also significant because of the limited amount remaining, as compared to their original number and acreage.

Table 11 gives the number and areal extent of wetlands in the counties included by the subbasin from the 1964 inventory conducted by the U.S. Fish and Wildlife Service. The 1964 data represents a 25 percent sampling. All numbers except for Type 1 have been multiplied by four to give 100 percent values for numbers and acreages of wetlands. Type 1 wetlands were not measured in the 1964 survey; however, previous studies have indicated that they comprise about 10-15 percent to total wetland acres and 60 percent

Table 11

1964 WETLAND INVENTORY DATA FOR THE FOUR COUNTIES INCLUDED BY THE PEMBINA RIVER SUBBASIN

	WETLAND TYPES[a]													
	1		3		4		5		10		11		TOTAL	
County	Number[b]	Acres[c]	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Pembina	14	23	19	75	4	77	0	0	0	0	0	0	37	175
Cavalier	10,095	5,989	16,525	36,955	292	2,940	8	33	0	0	0	0	26,920	45,917
Towner	7,963	5,637	12,765	29,315	439	5,025	28	2,896	28	182	12	164	21,235	43,219
Rolette	7,088	5,889	9,692	14,610	1,655	11,104	434	11,171	4	744	28	1,632	18,901	45,150

[a]Type 1 - Seasonally flooded basins and flats.
Type 3 - Shallow fresh marshes.
Type 4 - Deep fresh marshes.
Type 5 - Open fresh water.
Type 10 - Inland saline marshes.
Type 11 - Inland open saline waters.

[b]Calculated at 60 percent of total wetland numbers.

[c]Calculated at 15 percent of total wetland areas.

Source: U. S. Fish and Wildlife Service, 1979.

of total wetland numbers in the Prairie Pothole Region. This information was used to calculate Type 1 estimates. The 1964 data (expanded to 100 percent) is a conservative estimate. No acreage figures are available for wetlands drained and converted to cropland, but most have been drained in eastern North Dakota. Current annual wetland drainage estimates are thought to be less than two percent of the remaining wetland base, except in isolated areas where it may be higher (U.S. Fish and Wildife Service, 1979).

Waterfowl Production Areas

Waterfowl production areas (WPAs) are significant because they provide favorable nesting habitat for waterfowl. Additionally, these areas are heavily utilized by upland birds and other animals. WPAs are purchased or leased by the Federal government with funds received from the sale of Duck Stamps. Public hunting and trapping is allowed on the WPAs, in accordance with Federal and state regulations. Figure IV shows the approximate locations of 11 WPAs established in the subbasin. Table 12 presents total acreage figures for all the WPAs and wetland easement areas of the counties included in the subbasin. The wetland easement areas are included since they, too, provide valuable habitat for a variety of species. Both area types are managed by the U.S. Fish and Wildlife Service.

Table 12

WATERFOWL PRODUCTION AREAS (WPAs) AND WETLAND EASEMENT AREAS LOCATED WITHIN THE COUNTIES INCLUDED IN THE PEMBINA RIVER SUBBASIN

County	WPAs (Acres)	Wetland Easement Areas (Acres)	Total (Acres)
Cavalier	9,461	13,900	23,361
Pembina	2,142	139	2,281
Rolette	4,914	19,419	24,333
Towner	2,467	24,211	26,678
TOTAL	18,984	57,669	76,653

Source: U. S. Fish and Wildlife Service Fee and Easement Interests in Real Property, 1979.

Wildlife Management Areas

A total of seven wildlife management areas are found within the subbasin. A list of these areas and their acreages and locations were presented in the existing conditions section for recreation. These areas are considered significant because of the opportunities provided for outdoor recreation and protection and management given to biological resources within their confines.

Threatened or Endangered Species

Several animal species that are considered to be threatened or endangered in North Dakota have been reported from the subbasin. Endangered mammal species that have been recorded include the American elk, timber wolf, fisher, black bear, and cougar. All five of these species have declined in population, mainly because of pressure brought on by activities such as hunting and trapping for bounties, illegal hunting, and encroachment into their natural habitats (McKenna and Seabloom, 1979).

Four endangered or threatened bird species are known or presumed to occur within the subbasin: (1) bald eagle, (2) osprey, (3) American peregrine falcon, and (4) white-winged scoter. The white-winged scoter has been reported to breed in the Turtle Mountains within Rolette County. Egg collection by ornithologists, hunting pressure, and degradation of water quality has caused the gradual decline in the scoter's population. No recent breeding records of the other three birds have been reported from the subbasin, but the subbasin in included within the migratory paths of all three. The decline of these birds is a direct result of human activity, especially pesticide pollution such as DDT and its derivatives (McKenna and Seabloom, 1979).

The lake sturgeon, north redbelly dace, and trout-perch are the fish species found in the subbasin that are considered to be threatened or endangered. The lake sturgeon's decline has been influenced by overharvest, disruption of habitat and pollution. The northern redbelly dace frequents springs or areas near springs where there is plentiful vegetation and some sand or gravel. The destruction or disturbance of these spring habitats have caused the decline in the redbellys dace's population (McKenna and Seabloom, 1979). The trout-perch's populations have been

reduced mainly because of the construction of reservoirs and other such impoundments (U.S. Fish and Wildlife Service, 1979).

Other Important Species

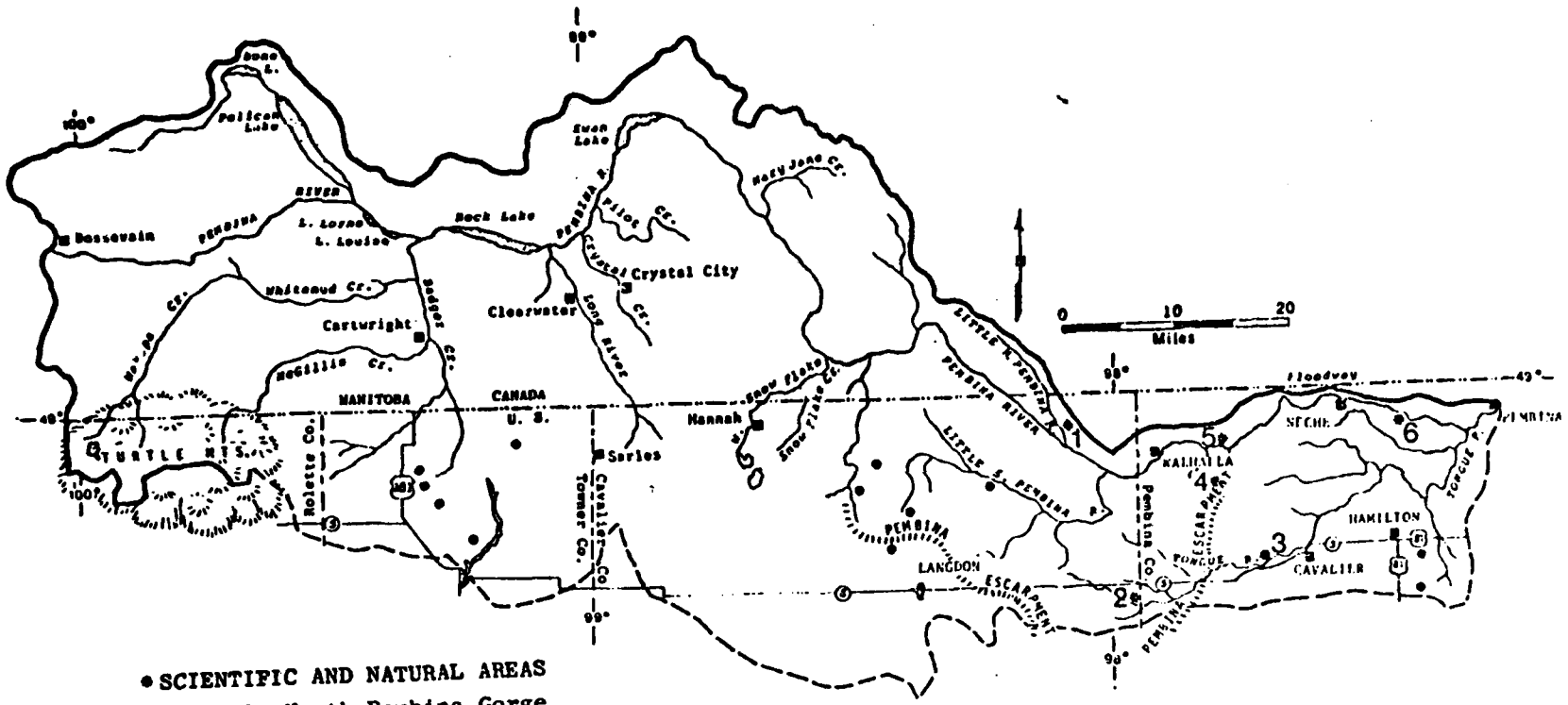
The other important animal species found in the subbasin are considered peripheral species. One mammal species, the Canada lynx, has been reported from the area. Five bird species are listed as peripheral: (1) pileated woodpecker, (2) chestnut sided warbler, (3) northern waterthrush, (4) mourning warbler, and (5) white throated sparrow. No reptile or amphibian is considered to be threatened or endangered, but one amphibian, the gray tree frog, is listed as a peripheral species that occurs in the subbasin. The central mudminnow, river shiner, blackchin shiner, and fine scale dace are fishes that have been reported from streams included in the Pembina River Subbasin and that are listed as peripheral species. The only confirmed report in Minnesota of the fine scale dace was from the Tongue River (McKenna and Seabloom, 1979).

Rare and Unique Plants

A total of 23 plant species that occur in the subbasin are listed by Barker et al. (no date) as being rare or unique species. To be included in Barker's annotated list, a species must be reported in no more than three counties. If, within these three (or fewer) counties, only a few individuals are recorded, then the species is considered to be rare. If there are many individuals at the recorded stations, then the species is considered to be unique (Barker et al., no date). Table 13 lists the 23 species reported from the subbasin.

Natural Areas

Kantrud (1973) listed six natural areas that are located within the Pembina River Subbasin. Two of these (the Little North Pembina Gorge and the Tongue River Gorge) are located in the eastern portion of Cavalier County. These two sites offer a scenic overview as well as habitats for wildife such as the scarlet tanager, lynx, northern waterthrush, oven bird, and moose. The other four natural areas are scattered throughout Pembina County: (1) Black Ash Woods, (2) St. Joseph Woods, (3) McLarty Grove, and (4) Arka Grove. All of these sites are comprised of bottomland



- SCIENTIFIC AND NATURAL AREAS
  1 Little North Pembina Gorge
  2 Tongue River Gorge
  3 Arka Grove
  4 Black Ash Woods
  5 St. Joseph Woods
  6 Mc. Larty Grove
- WATERFOWL PRODUCTION AREAS

Source: State Comprehensive Outdoor Recreation Plan, 1975; Kantrud, 1973.

Figure IV. WATERFOWL PRODUCTION AREAS AND SCIENTIFIC AND NATURAL AREAS WITHIN THE PEMBINA RIVER SUBBASIN

V. FUTURE CONDITIONS

The subbasin's future economic, social, and environmental conditions and resources are discussed below in terms of "most probable" and "without project" conditions.

Most Probable Economic Conditions

Communities and businesses in central and western Pembina County and, to a lesser extent, in Cavalier County underwent severe economic disruptions in the late 1970's following the deactivation of several defense installations in the area. Economic adjustment plans were formulated, and a sizable effort is being devoted to economic diversification, with emphasis on agriculture-related processing and indigenous industries. Because of these employment losses, the population and employment increases (seven percent) that were noted in Section IV as having taken place between 1970 and 1977 are not indicative of the future of this subbasin. The data presented in Table 14 below assumes a 1980 population level similar to the one estimated for 1977. A modest one percent per decade increase is forecast thereafter, based on similar experiences in areas with similar dislocations coupled with agricultural employment stabilization.

The figures in the table were adopted in lieu of the prescribed OBERS E projections, because those projections appear to underestimate growth patterns for the Grand Forks area, both metropolitan and environs. Steady declines through the year 2020 are anticipated by this series. OBERS E and E' projections were, however, designated as the most probable for per capita income and agricultural activity estimates.

Farming will continue to be the economic mainstay of the subbasin, with communities such as Pembina, Walhalla, Cavalier, and Langdon as employment, service, and retail centers for the large agricultural base. Grafton will continue to serve as the primary retail and wholesale center. Local leaders and area planners point to the need for diversification and possible inundation of some 90,000 flood-prone acres and the towns of Pembina, Neche, and Walhalla as the biggest obstacles to economic growth.

Table 16

PEMBINA RIVER SUBBASIN, SUMMARY OF PRESENT AND FUTURE AVERAGE ANNUAL DAMAGES
URBAN, AGRICULTURAL, AND TRANSPORTATION
(October, 1979 Prices, 7 1/8 Percent Interest)

Category	Flood Damages						Increase 1980-2030	Average Annual Equivalent Factor	Average Annual Equivalent of Increase	Equivalent Average Annual Damages
	1980	1990	2000	2010	2020	2030				
Urban										
Pembina	150,000	165,000	180,000	195,000	210,000	225,000	75,000	0.2903	21,800	171,800
Neche	30,000	33,000	36,000	39,000	42,000	45,000	15,000	0.2903	4,400	34,400
Walhalla	25,000	27,500	30,000	32,500	35,000	37,500	12,500	0.2903	3,600	28,600
Agricultural										
Crop	1,801,400	2,089,600	2,377,800	2,558,000	2,738,100	3,026,400	1,225,000	0.2903	355,600	2,157,000
Other Agricultural	600,500	648,500	696,600	726,600	756,600	804,700	204,200	0.2903	59,300	659,800
Transportation	227,000	227,000	227,000	227,000	227,000	227,000	----	----	----	227,000
TOTAL	2,983,900	3,190,600	3,547,400	3,778,100	4,008,700	4,365,600	1,531,700	0.2903	444,700	3,278,600

Source: Gulf South Research Institute.

- does this represent an estimate of future crop values? answered on next page, 5th paragraph

Woodland acreages will deteriorate unless the state is sucessful in obtaining ownership of the extensive native forests in the subbasin. This problem was discussed in the Problems and Needs section of this report. Although the state has placed a moratorium on wetland drainage by government agencies in the upper part of the subbasin (U.S. portion), drainage on private lands continues. The U.S. Army Corps of Engineers (1977a) indicated that the drainage rate should decrease because of the following reasons:

1. The majority of small shallow wetland areas in the upper basin have already been drained and converted to agricultural uses.
2. Pressure by various interest groups will probably cause existing water management boards responsible for providing permission for all drainage projects, including private drainage, to exercise their responsibility more conscientiously on the remaining wetland areas.
3. A cooperative approach to drainage problems similar to that being applied to the adjacent Devils Lake Subbasin has been suggested by several interests.
4. For the most part, drainage of U.S. lands in the upper Pembina River Subbasin crosses the International Border into Canada. The general rule governing these drains and creeks is that they may be maintained but not enlarged.
5. The above points indicate the increasing importance of land use planning, which should have a significant influence on future changes in existing land use.

Even though the drainage rate may decrease, the important point is that it will probably continue with the resultant effect of reducing the number and areal extent of this important resource.

Commensurate with the expected reduction of woodlands and wetlands, is the decrease in plant and animal populations associated wholly or in part with these habitat types.

Without Project Conditions

In the absence of a plan to alter resource management procedures, it is anticipated that the conditions that will prevail between 1980 and 2030 will be the same as those described as being the most probable.

Pembina River Basin Association

Concerned for Wildlife, Flood Control, Irrigation, Recreation, Environment

Attention of:
NCSED-FB

Neche, N. D.
July, 15, 1980

William W. Badger
Colonel, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minn. 55101

Re: Comments on Pembina Basin study report

Dear Col. Badger:

The draft study report of the Pembina River Subbasin has been reviewed. General concurrence is given to the report in addressing the problems, needs, and concerns of the subbasin in the U. S. alone.

However, there are a few specific corrections and additions that need mentioning.-

1. With reference to the last sentence in paragraph 1, page 29, the year should be 1974, instead of 1975.

* 2. On page 34, under the topic of Water Supply, in addition to the river water scource of supply for the cities of Langdon and Cavalier, the city of Pembina is annually using about 30,000,000 gallons from the Pembina River. Also, the cities of Neche, Gretna and Altona are using about 140,000,000 gallons annually from the same scource. We know of no small communities depending on wells or small dugout reservoirs for potable water uses as stated, except for livestock.

3. On page 39 the Frost Fire Mountain Ski Resort, Walhalla Country Club, Pembina Golf Course, and Walhalla Golf Course are all located improperly on the map.

* 4. Referring to the last sentence in paragraph 1, page 59, the snagging study was not terminated because of lack of support at the local level. Local people and agencies declare it to be a vital need.

5. On page 63, an additional objective would be proper. Namely, the importance of installing slow release structures in drains that have drained natural water holding areas in the upper reaches of the Basin.

6. Referring to the last paragraph on page 64, the belief here is that flood damages along the main stem and lower subbasin would be significantly lower than the figures indicated, on completion of the Pembina Project.

7. On page 74 in paragraph 2, contrary to the statement made, there is no evidence that the Project will destroy existing ecosystems of floodplain forests, or have a detrimental effect on wildlife well beyond the limits of the design pool level. The facts are, in the last number of years, the floodplain has been subjected to many more inundations than older history records. So a change will be forthcoming to the floodplain ecosystems unless the Project is completed. As to detrimental wildlife effects, not mentioned are the sustantial offsetting wildlife benefits occurring with the Project.

We are pleased to have had an opportunity to review your draft report on the Pembina Subbasin and make comments thereon.

Respectfully,

Grant Trenbeath
Chairman

ST. PAUL DISTRICT, CORPS OF ENGINEERS
GENERAL COMMENTS
DRAFT PEMBINA RIVER SUBBASIN REPORT
(JUNE 1980)

(These comments apply to the entire report and all subsequent subbasin documents.)

1. Comments from Federal, State, and local agencies and a letter (with comments) from the St. Paul District will be included in an appendix in each final subbasin and in the overall report. The format for the appendix will be:

a. Introduction - This section should stress:

(1) The importance of completing the study on time.

(2) That the purpose of the study is to advise other agencies and interests.

(3) The need for a selected review by various interests to provide complete and factual documentation.

(4) The use of the study as a building block for future water resource efforts.

(5) That cooperative efforts to evaluate results and develop solutions to remaining problems will be incorporated.

(6) A complete public involvement program when the study is finished.

b. The distribution list.

c. Copies of letters of comment.

Only comments that identify significant errors or need specific attention will be addressed in the final subbasin report. However, all comments incorporated should be identified with a marking system. The distribution list for the Pembina River subbasin report is given below:

Agencies receiving draft report	Date sent	Date comments received
Federal		
Soil Conservation Service	1 July 1980	16 July 1980
Fish and Wildlife Service	3 July 1980	19 August 1980
Corps of Engineers, North Central Division	2 July 1980	18 July 1980
Corps of Engineers, St. Paul District	1 July 1980	10 July 1980
State		
North Dakota State Water Commission	1 July 1980	16 July 1980
North Dakota Game and Fish	3 July 1980	-
North Dakota State Planning	3 July 1980	-

Agencies receiving draft report	Date sent	Date comments received
Local		
Flood Control Association	3 July 1980	15 July 1980
Water Management District	3 July 1980	-
Red River Region Planning Council	3 July 1980	-

2. The evaluation section of each report is primarily the recommendations of the document. Generally only the structural alternatives which have a benefit-cost ratio greater than 1 are presented. Little attention is given to the other structural and nonstructural alternatives that may be important aspects of future flood damage reduction planning for the subbasin and basin as a whole. Some of these alternatives may provide the necessary environmental conditions to warrant future efforts. Therefore, it is recommended that this section be expanded to provide the appropriate discussions.

3. The supporting information for alternatives, including technical economic, and any environmental data, should be provided (at least under separate cover). This would simplify matters when questions are asked during review or in the future.

4. The maps should have more detail. Often information in the text is not clearly illustrated on the maps. These maps would be improved if reproductions were of better quality and included township lines or relationships of the subbasin to counties or State lines.

5. The Corps is presently undertaking a Section 14 (Emergency Streambank and Shoreline Protection of Public Works and Nonprofit Public Services) Reconnaissance Report at Neche, North Dakota. If implemented, this project would probably not have a major impact on the subbasin; however, this study should be referenced.

6. Occasionally is often misspelled.

7. The Final Environmental Impact Statement, Pembilier Lake and Dam, Pembina River Basin, North Dakota (1977), was never approved for release and therefore all references to this document are not valid. Instead, the Draft Environmental Impact Statement for the project dated November 1976 should be referenced. All inappropriate references should be corrected.

ST. PAUL DISTRICT, CORPS OF ENGINEERS
SPECIFIC COMMENTS
ON THE
DRAFT PEMBINA RIVER SUBBASIN REPORT
JUNE 1980

*1. Page 2, No. 4 - The project at Pembina has been constructed and therefore the word "proposed" should be deleted.

*2. Page 2, No. 9 - See general comment 7.

3. Page 8, paragraph 4 - The 10-percent contribution of flow should be identified as either peak discharge or volume.

*4. Page 8, Location and Extent Section - The 100-year floodplain for the Pembina River is well defined. Therefore, the second sentence needs modification. Also, the floodplain map identified in Figure II should be enlarged.

5. Page 16, Recreational Problems Section - The "intermittent flows" and "water quality problems" appear to conflict with information on pages 16, 17, 34, and 42 that states, "The water quality in the Pembina River is considered good for recreation and fish and wildlife purposes." This conflict should be corrected.

*6. Page 18, Irrigation Section - The last sentence seems to conflict with statements made on pages 17 and 34. Also, the IJC report discussed irrigation in detail. Some discussion of their findings should be included in this section.

*7. Page 18, Hydropower Section, line 3 - "Six" should be "ten."

8. Page 20, Public Perception of Problems and Solutions Section -

a. People from this subbasin are extremely active in water resource activities throughout the Red River basin. Their participation at meetings and on committees should be referenced.

* b. See general comment 7.

c. The recommended plan identified in paragraph 3 should be specified.

9. Page 23, Employment Section -

a. Unemployment should be given in 1970 and 1978 figures since references in the ABM facilities employment are given in 1978 figures.

b. Since a major employer is gone from the area, the 7-percent unemployment should have increased significantly over the last 2 years. This should be referenced.

Incl 3

10. Pages 23 and 24, Income Section - The per capita income increase for the State should be given in both 1969 and 1979 values.

*11. Page 26, paragraph 1, line 6 - "western" should be "eastern."

12. Page 26, Land Use Section - 100 percent of the land use should be identified.

13. Page 27, Geology Section - There are cretaceous shale deposits exposed in the Pembina River Valley located at approximately the Pembina/Cavalier County line. This is the oldest exposed rock formation in North Dakota and should therefore be mentioned in the report.

14. Page 29, paragraph 1 - According to available information, it appears that type 10 and type 11 wetlands are not present in the basin and should be deleted from the list of wetland types in the basin.

*15. Page 29, paragraph 2 - The sentence on the woodland's value to wildlife should read, "The woodland and brushy areas provide breeding, reproduction feeding, loafing, and escape cover for many resident and migratory wildlife species."

16. Page 30, paragraph 1 - The comparative discussion on habitat productivity should be more consistent. Because breeding bird densities are the comparative parameter, they should be listed for each habitat type being compared.

*17. Page 33, paragraph 2, last sentence - The sentence should be deleted because it is repetitious of that made on page 31, paragraph 2, last sentence.

18. Page 34, Water Supply Section -

a. The statement that sufficient quantities of groundwater exist for domestic purposes is in conflict with statements made on page 17. This problem should be resolved.

b. The section should also mention that Neche uses water from the Pembina River and supplies Gretna and Altona, Canada, with water. The city of Pembina also uses Pembina River water. No communities use wells or dugout reservoirs.

19. Page 37, Cultural Elements Section -

*a. In line 6, "B.P." should be "B.C.".

b. The 1975 Ames survey located 19 archeological sites in the area of the proposed Pembilier Reservoir in Cavalier County. Sixteen of these sites are recorded and there is one recorded in Pembina County. This should be stated in the report to clarify the statement "relatively few recorded archaeological sites". It also would reinforce the statement on page 38, paragraph 2, line 8 concerning the association of cultural resources and major streams.

c. Surveys will also be needed to inventory archeological (prehistoric) sites in the Pembina subbasin.

20. Page 39, Figure III - Items (2), (1), (2), and (3) are improperly located.

21. Page 40, Social Section - The city of Pembina is protected by a permanent levee and floodwall constructed by the Corps of Engineers. Only South Pembina is not presently protected. Therefore all discussions on flooding at Pembina should be modified accordingly.

22. Page 42, paragraph 1 - The fishery value of the basin is overestimated. As stated in the Report of the Ecological Advisory Subcommittee to the Pembina River Basin Planning Committee, November 8, 1971, "Although the Pembina River supports a small fish population, it lacks sufficient summer flows to maintain large numbers of fish attractive to fishermen."

*23. Page 45, Threatened or Endangered Species Section - The discussion should distinguish between federally listed threatened or endangered species and State listed threatened or endangered species. Also, in line 12 from the bottom of the page, "in" should be "is."

*24. Page 49, Figure IV - This should be after page 44.

25. Page 50, Most Probable Economic Conditions Section -

a. Despite a per capita increase from 1969 to 1977 of only 6.4 percent, and the "severe econor c disruption of the late 1970's . . ." (page 50), the study forecasts a 31-percent increase in per capita income from $5,480 (1977) to $8,000 (1980), and only a 23-percent increase from 1980 to 1990. What is the rationale behind this deviation?

b. Additional discussions should be presented to relate the economics or the subbasin social conditions to the Grand Forks patterns.

*c. The last sentence on page 50 is unclear. It sounds like Pembina, Walhalla, and Neche are subject to total inundation. This is not valid for Walhalla and Pembina. This should indicate "the threat of possible inundation."

26. Page 52, table 15 - The discussions should indicate what assumptions are used to consistently increase the wheat and barley production.

27. Page 53, table 16 - The equivalent average annual damages for Pembina appear too high. A majority of the town is protected by a permanent project. Please review and modify the numbers.

28. Page 54 - The assumptions behind the 1-percent straight-line annual growth rate of urban flood damages should be identified.

29. Page 56, Institutions Section -

a. The Pembina River Flood Control Association should be identified and its activities and attendance at meetings discussed.

*b. The Pembilier Lake multipurpose project is authorized for Phase I General Design Memorandum studies only and not for construction.

* 30. Page 59, paragraph 1, last sentence - The Pembina River snagging and clearing project was not terminated because of lack of local support. It was terminated because the local costs were too high. Local support was evident but the costs to locals kept increasing until they surpassed the Federal authorized limit. This sentence should be modified accordingly.

* 31. Page 61, last sentence - The conclustion that ". . . additional structural measures are needed. . ." seems unwarranted in view of the discussion of nonstructural measures on page 60. Suggest deleting the word "structural."

* 32. Page 62, last paragraph - After ". . . subbasin." add "from the information available."

* 33. Page 64, item 1 - See specific comment 29 (b).

34. Page 66, item 5 - The preliminary studies referenced are those accomplished in the Aux Marais watershed which does not drain into the Pembina River. Therefore, item 5 should be deleted.

35. Page 68 -

a. The flood warning paragraph is unclear. This paragraph actually discusses flood warning only in combination with temporary structures, which are not specifically named or exemplified ("emergency works" does not prepare the reader to understand "structural stability problems" and "greater danger of failure").

b. Emergency protection measures are not a source of "inconvenience and disruption" (the flood is). Instead, they are protection.

* 36. Pages 70-72 - The farmstead levee alternative (No. 6) is assessed but it is not included in the formulation section. This should be corrected.

37. Page 72, paragraph 4 - The maximum beneficial economic effects for the Pembilier Reservoir and the minimum beneficial economic effects for the farmstead levees seem to conflict. This should be corrected in the text and on tables 17 and 18.

38. Page 73, table 18 -

a. It would be most helpful if the text of the report would include an explanation of how the assessments were made. For example, measure number 1 will effectively destroy 17 to 19 archeological sites, maybe more. How does this rate a "moderately adverse" effect?

b. "Unknown effect" would be a more accurate assessment than "no known effect". "No known effect" implies that studies have been done and no adverse effects were discovered.

39. Page 74, paragraph 2, last sentence - The statement on eutrophication should be in the paragraph on water quality.

*40. Page 74, paragraph 3, 1st sentence - The comment "although moderately," should be deleted. There is not sufficient available information to qualify the degree of eutrophication.

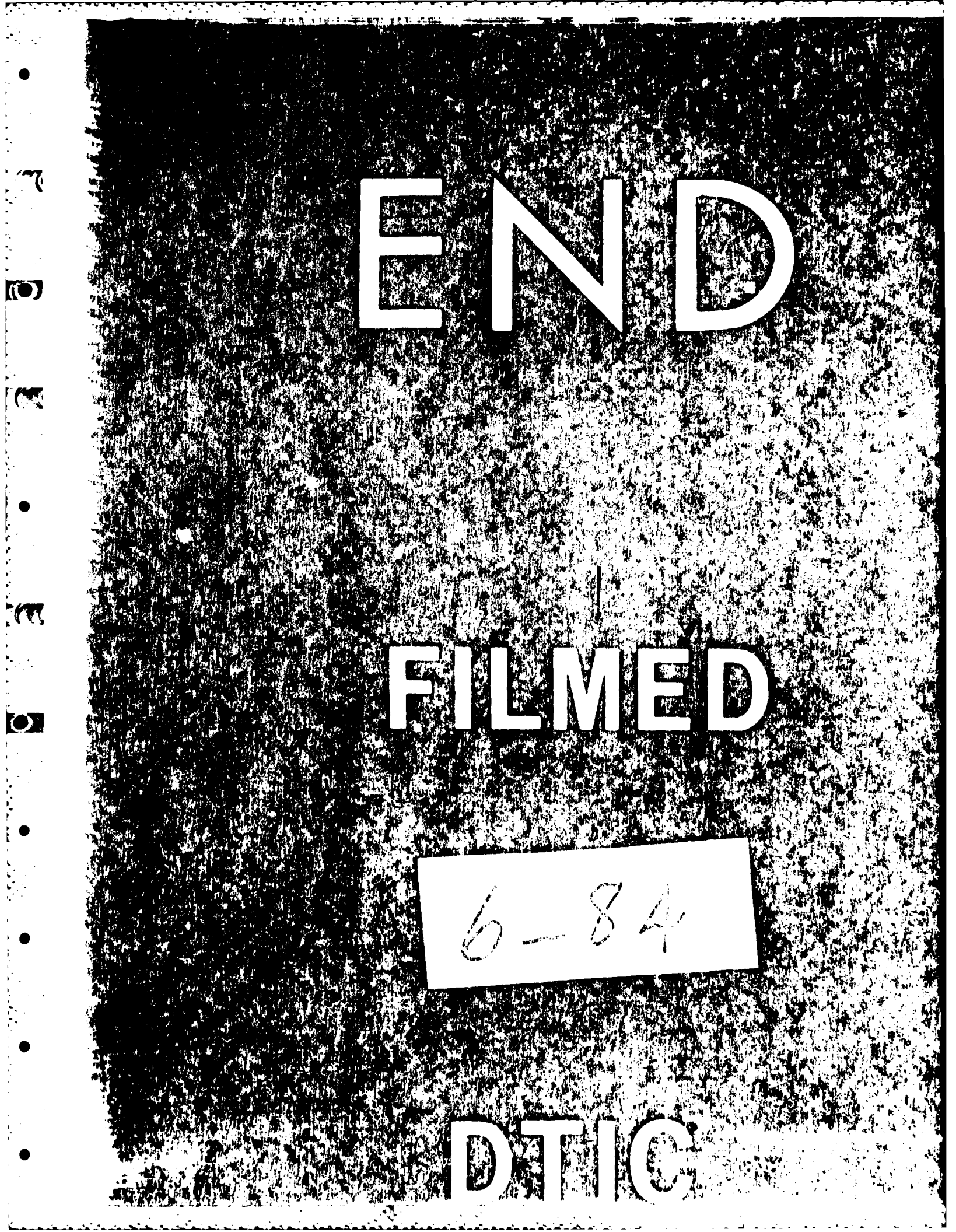
*41. Page 74, paragraph 5, line 3 - The 19 archeological sites will not be "affected" - they will be destroyed.

*42. Page 75, paragraph 2, line 9 - It is stated that urban levees at Neche will have no or negligible effects on cultural elements. On the chart on page 73 it says "no known effect". This is an inconsistency.

43. Page 76, paragraph 3 - How many farmsteads need or could benefit from such levees? ("Several" is too vague.)

44. Page 77 - The sentence "The Environmental Quality (EQ) account would receive basic changes, several of which are negative" obscures its message, which is that Pembilier Lake has the most severe environmental consequences. Clarify this, then discuss the EQ plan in a third paragraph.

45. Item 26 - "Archeological" and "historical" are not mutually exclusive. "Archeological" may be separate from "standing structures" and "historical" from "prehistoric".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